

CHEMICAL & METALLURGICAL ENGINEERING

New York, May 1, 1919

McGraw-Hill Company, Inc.

Vol. XX, No. 9. 25c a copy

"Buflovak" and "Buflokast" Products

Apparatus that is aiding America's chemical and allied industries produce superior products at low manufacturing cost and secure valuable by-products from waste materials.

"Buflovak" Evaporators

Horizontal Tube, Rapid Circulation, Vertical Tube and High Concentrator types.

"Buflovak" Vacuum Apparatus

Drum, Shell and Rotary Dryers, Crystallizers, Condensers, Impregnating Apparatus, Solvent Recovery Apparatus, Dry Vacuum Pumps, etc.

"Buflokast" Chemical Apparatus

used in producing Heavy Chemicals, Acids, Caustic Soda and other alkalies, Organic Chemicals, Coal Tar Intermediates, etc.

Buffalo Foundry &
Machine Company
1543 Fillmore Ave.
Buffalo N.Y.

"BUFLOVAK"



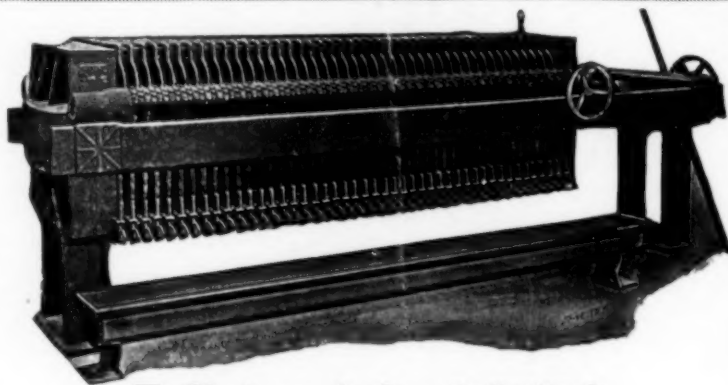
"BUFLOKAST"

**For Big Production and Low
Operating Cost
SHRIVER
FILTER PRESSES**

They increase output and effect marked savings in filter cloth replacements and the recovery of values. Little attendance and less wash water adds to their economy.

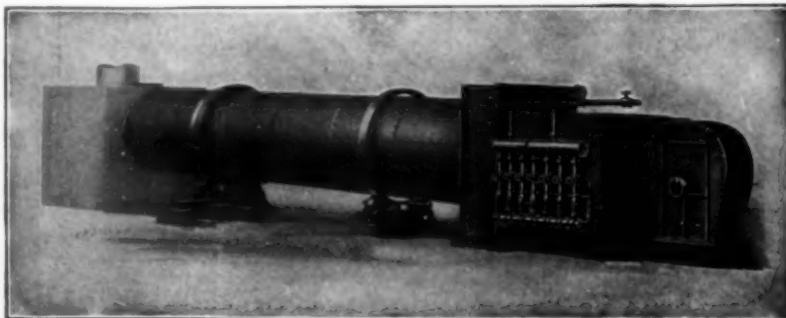
Have wide joint surfaces. Accurate finishing of plates and frames, coupled with an efficient tightening device, prevents leakage.

Presses for all industrial filtration. Small presses for laboratory work.



T. Shriver & Co., 808 Hamilton St.
Harrison, N. J.

STEAM HEATED AIR DRYERS



for drying Borax, Nitrate of Ammonia, Baking Powder, etc.

Have equipped largest chemical plants in the world.

Also Direct Heat Dryers for By-Products.

Material carried in stock for standard sizes.

American Process Co.
68 William St., New York

Take DRYERS for instance



A dryer for washed rubber sheets, designed to meet the requirements of the New York Belting & Packing Co., Passaic, N. J.

Among the many applications of air conditioning apparatus drying is, perhaps, the most important, industrially.

The manufacturer of a "standard" dryer, in so many sections, must, necessarily, adapt *your* manufacturing conditions to meet the possibilities of *his* dryer.

We have been designing and installing dryers for sixteen years, but we have never tried to develop a "standard" dryer, because every drying problem is individual; either the product requires a carefully engineered process, or your manufacturing routine has been developed, or is to be developed, along lines which make it desirable for the dryers to conform to *your* conditions.

So, instead of developing a "standard" dryer, we have studied the fundamental principles underlying *all* drying—and we have developed mechanical equipment which enables us to efficiently apply these principles to *your own* drying requirements.

We'll be glad to co-operate with you in the solution of any drying problem—or wherever air conditioning equipment can profitably take its place in your business.

Have you read our bulletins?

Write right now.

"Every day a
good day"



Carrier Engineering Corporation

39 Cortlandt St., New York, N. Y.

Boston

Buffalo

Chicago

Philadelphia

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.

Tenth Avenue at 36th Street

NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4. BUENOS AIRES, Calle Corrientes, 685.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

Yearly Subscription price for United States, Mexico and United States dependencies, \$3; all other countries, \$4. Single Copy, 25c. When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 12,900 copies

CONTENTS for May 1, 1919

Volume, XX, Number 9

EDITORIAL

National Integrity, Personal Responsibility and the Victory Loan	449
Has Heat Treatment Been Demonstrated?	449
Bolsheviks and Research	450
The Way to Prosperity	450
Alignment of the Steel Industry	451

READERS' VIEWS AND COMMENTS

Rapid Electrolytic Copper Assay Without Rotating Cathode. By Richard G. Place	452
The Perchloric Acid Method for Potash in Cement Materials. By William P. Newberry	452
Credit to Whom Credit Is Due. By Fred Petzold	453
Flakes in Steel. By Haakon Styri	453
Standard Form for Mexican Claims	453
Bids Requested on Chlorine	453
Western Chemical and Metallurgical Field	454
Symposium on Pyrometry at Fall Meeting of the A. I. M. E.	455
Use for Surplus TNT	455
Imports of Tungsten-Bearing Ore	455
Import License Proposed	456
Merck Stock to be Auctioned	456
New Jersey Chemical Society Spring Meeting	456
American Bureau of Welding	456
"Hamlet" With Hamlet Left Out	457
Metallic Coatings for Rust-Proofing Iron and Steel—I. By Henry S. Rasdon, M. A. Grossman and A. N. Finn	458
Potash From Wood Ashes	464
War Department Disposes of Lead	464
Treatment of Cuprodescloizite for Extraction and Recovery of Vanadium, Lead and Copper. By J. E. Conley	465
The Edgewood Arsenal	469
The Oxidation of Ammonia. By W. S. Landis	470
Lead Poisoning	477
Flaky Fractures and Their Possible Elimination. By Haakon Styri	478
Request for Quotation on Borax	483
Metal Strapping on Wooden Boxes	483
Recovery of Waste Paraffined Paper	483
Bituminous Roofing Materials and Construction—II. By George Landis Wilson	484
Recent Chemical and Metallurgical Patents	487
Vom Baur Electric Furnace. By C. H. Vom Baur	488
Personal	489
Current Market Reports	489
Imports and Exports	492
Industrial, Including Construction and Operation, Coming Meetings and Events, Industrial News, New Publications and Stocks and Bonds	495

National Integrity, Personal Responsibility and the Victory Loan

OUR soldiers are coming home. On April 25 over 23,000 arrived in New York harbor, and each day sees thousands more returning to resume their places as civilian workers. Hundreds of thousands still remain in Europe to finish the job they started; and seventy thousand, more or less, who represent the price in human life which the United States paid for world peace, sleep under the little white crosses that mark our soldiers' graves in France. Upon us devolves the welcome duty of paying the money debt incurred by the vast preparations necessary to support those thousands who are now returning, and those other thousands who made the supreme sacrifice.

Speaking of sacrifice, how little the average American citizen knows about it in connection with the war. None went hungry or naked; all slept peacefully, secure from invasion, pillage or death; few gave up luxuries and fewer still denied themselves necessities; except for a few gasless Sundays, our automobiles worked about as usual; Liberty bonds were bought out of our abundance, and created a bigger capitalist class than the country ever knew before. We knew not the terror of the air raid or the long-range bombardment, nor did we see the flower of our youth fall by the million in battle until our whole nation was in mourning. It is scarcely becoming to speak of sacrifice on the part of the majority of our people.

The work is yet to be finished, and the Victory loan is made for that purpose. As portrayed in the colored supplement to this issue of CHEMICAL & METALLURGICAL ENGINEERING, Liberty makes this final appeal in the name of those whose graves dot the soil of France.

Has Heat Treatment Been Demonstrated?

ONE is accustomed, when thinking of things connected with the manufacture of modern machine parts, to assume that heat treatment actually has been demonstrated. That is to say, that factory or shop executives universally recognize the fact that the physical properties of metallifatures may be altered and adjusted by a properly selected schedule of heating and cooling.

But evidently not so! A case in point occurred in the year of grace 1918, in a shop belonging to a huge Western railroad system. The mechanical engineering authorities were evidently wide awake; they knew the elastic limit and ductility required for various engine repair-parts, and these properties were specified and obtained. The forge shop was well in line, too; for instance, when making locomotive driving rods, special attention was given to produce a finished piece which would forthwith pass the rather exacting physical re-

quirements, and in order to reduce the discouragingly large number of rejections, the foreman had installed a pyrometer in his heating furnace, which was carefully kept at a certain reading.

Still rejections were even at best all too common—perhaps two for every good rod produced. Of course these beautiful heavy forgings were not altogether lost, for some economical body decided to cut them up for smaller pieces of less importance whereby many dollars were saved to help Uncle Sam win the war!

One day a metallurgist from a steel company was at these shops endeavoring to adjust a purchasing-department claim. He noticed a big side-rod in process of demolition and on inquiry discovered the conditions just outlined. Being naturally curious, he inquired why an effort was not made to adjust the physical properties of the completed forging by an anneal, and was startled by the information from the shop superintendent, "One of our men thinks that some of them might be passed in that way, but heat treatment is still in the experimental stage and we are in no position to monkey with it. All our energies are required for production." This certainly was a poser, but the inquisitive visitor was militant as well, and on a long-odds wager, placed three excellent but rejected rods in an end-fired tunnel furnace—the only thing immediately available—turned on the flame, heated them until one portion began to color, then let them soak for a time, and repeated the process until the bars had gradually passed the transformation range—judging temperatures entirely by eye. After cooling from this crude operation, fresh tests from the forgings passed the ductility limit easily.

The foreman paid the wager with a smile, as well he might, since the gain was a hundred dollars for each one lost, yet he retains the original practice! What will get beneath the skin of "rule-of-thumb," "practical" methods, anyway?

Bolsheviks and Research

PROBABLY few would dispute the assertion that there is no industrial research now under way in bolshevik Russia. True, the civilized world lacks definite knowledge as to this and other particular points, but by inference the statement is approximately correct. If a governing body decides that executives of industrial enterprises are excrescences on the body politic to be forthwith lopped off, surely the workman-managers do not need a bespectacled scientific staff to tell them how to improve process, performance or production.

Americans, especially Americans who are managers or directors, think of bolshevism and soviets as a child thinks of bogey-men, and any one of them would hotly resent any insinuation that his mental processes were bolshevikian—devil take it and all its works! But in more than one recent instance, such a manager or such a director has started to "reduce the cost" of his product by eliminating that most essential part of his technical organization, the research staff. A bolshevist would have pushed his mistaken idea to the limit, though. He would have fired the manager, the auditor, and even the director himself. The insinuation is, therefore, immediately withdrawn.

Doubtless it is only reasonable to presume that research organizations instituted during the affluence of war-times should be regarded as non-essentials, and their appropriations refused before their work was well

under way, when the product is not selling with its former ease and volume. Such a research was instituted, not because the management realized the need for it, but because it was stylish, or because the concern had more money than it cared to turn over to Uncle Sam. Luxuries and side issues can now be dispensed with, it is true; but it is truer that properly organized research is neither a luxury nor a side issue.

It is almost an axiom derived from experience that the surest way to increase the use of an article is to cheapen its cost so that it can be marketed at a lower price. Now in the ultimate analysis, the cost of any article, no matter how simple or how intricate, depends upon the money spent for labor and the money absorbed by capital, taxes or royalties—in brief, for "labor" and for "capital." At times even the directors have aimed to reduce costs, always by the doubtful expedient of cutting labor rates, seldom touching capital costs except as a last resort. The technical management, on the other hand, often has the best will in the world to reduce labor costs by increasing the efficiency of the men and machines, but, pray, who is to point the way in which more production can be had from a dollar's worth of raw materials or an hour's human labor, if it is not the research department?

This argument is almost self-evident to the technical man. It may happily reach and convince the executive. His conversion would doubtless be easier if he could realize that by increasing labor and technical efficiency is found the only way in which present capital charges can be maintained. But human nature is the same everywhere—even in high places they buy dear on a rising market, and scramble to sell when things are cheap!

The Way to Prosperity

LET us try to clear the industrial atmosphere with a few plain truths. First: We are not going to return to pre-war conditions, economically, socially, industrially or commercially—nor do we want to. Second: Economic law is as basic and sound as scientific law or engineering fact, and disaster is quite as certain to overtake those who violate the one as those who ignore the other. Third: The people now need education in economics even more than prior to the war, so that certain fundamental facts will be widely understood and appreciated. Fourth: Failure to realize and accept the changes, and ignorance of their cause, is largely responsible for the lull in business activity—the valley of depression in the curve of industry and commerce; conversely, a knowledge of fundamentals would remove hesitancy, uncertainty and gloom, and enable business to step forward with confidence and cheerfulness.

Fortunately for all of us the voices of the economist and sociologist are being heard in the land, but they need reinforcement and transmission to a larger audience. It seems scarcely necessary to attempt to prove that pre-war conditions generally have gone for good. The war itself was a social revolution, a protest against autocracy in politics. Is there anything startling in the corollary that autocracy likewise must be removed from industry? This explains the social unrest, the aspirations of the worker, the necessity for recognizing a new order in human relations. Likewise the war caused an inflation of currency and credit that is responsible for the high prices of commodities, and the establishment of a permanent new high-price level in

business. Prices are not going back to pre-war levels, as a general proposition, and wages must remain high in order to meet the increased cost of living. There will be changes until the most glaring discrepancies are removed, but in general prices and wages are up to stay. If the changes are proportionate, we are all just as well off as before. The great necessity is to realize the futility of talking about lower prices and wages or waiting for them to come.

In an analysis of the causes for present prices, MR. O. P. AUSTIN, statistician for the National City Bank, New York City, finds that the first contributing cause was a "scarcity demand" for war materials. This cause, however, would not explain the concurrent rise in prices of commodities that found no place in war and for which no war demand existed. Looking deeper into the matter, he finds that world inflation of currency is the fundamental cause, paper money with a face value of \$36,000,000,000 having been issued by the countries at war, excluding the currency issued by the bolsheviks. Practically all of this is an acceptable medium of exchange in the country of its origin. Add to this the \$180,000,000,000 of bonds that the responsible nations of the world have issued, and which are in effect a basis for obtaining money; and the \$50,000,000,000 increase in world bank deposits, and we are not surprised when MR. AUSTIN pertinently observes:

"If the world's historians and financiers and economists and statisticians are right in their general belief that any advance in prices usually accompanies or closely follows inflation in currency, and especially in paper currency, can we be surprised at the world-wide advance in prices which we have witnessed during the past four years in which world currency and bank deposits trebled and national debts quintupled?"

Deflation is not in sight, and that is the only hope for materially lower prices. Isn't it about time to rely upon the laws of economics and go ahead with business? The question answers itself. Intelligent conclusions drawn from the facts point irresistibly toward resumption of business, realizing that the change that has taken place is one of degree only, and that the great need of the hour is a combination of optimism and wisdom that will bring about resumption by resuming.

Alignment of the Steel Industry

THE steel industry has been the "prince or pauper" industry so long and it has so generally been regarded "the barometer of trade" that we have insensibly fallen into the habit of regarding it as a foregone conclusion that if business is good the steel industry will thrive, while if business is not good the steel industry will languish. That is, the steel industry has nothing to do with its own destiny. It is assumed to come about naturally that the industry is too small when times are good and too big when times are bad. After all, however, it would be decidedly curious if such a doctrine should work out right all the time.

On the one hand, the war caused the American steel industry to expand greatly, productive capacity having increased by fully 40 per cent since 1914. On the other hand, the war stopped nearly all construction work, and it is in construction work that steel finds its chief demand. It is true that tin cans are used but once, that wire fence rusts away and that some steel is used in making tools, automobiles and various things that have

but a limited life. The heaviest employment of steel is in construction works, which are established as investments, in bridges, factories, hotel and office skyscrapers, power plants, transmission lines, oil and gas pipe-lines and similar enterprises. What is the balance between the increase in steel-making capacity and the halt in construction work, both caused by the war?

Existing capacity should be compared with production or consumption before the war rather than with capacity at that time. In the five years, 1905 to 1909 inclusive, the production of steel ingots in the United States averaged 20,325,000 tons a year. In the next five years, through 1914, the average was 26,313,000 tons. Capacity at present is about 50,000,000 tons.

Plainly this is a very large increase to be taken care of. It is true that pig iron production has very nearly doubled every ten years, while the production of steel has increased somewhat more rapidly; but if it were possible to divide all steel consumption, year by year, into transitory and permanent use, into classes represented respectively by tin cans and beams, it would probably be found that the latter class has increased more rapidly than the former. No point is strained, by the way, in using the tin can as an illustration, for the production of tin plate in the past two years has been at a greater rate, in point of tonnage, than the production of all structural shapes in any year prior to 1905.

The demand for steel for construction purposes rests upon no whim, but upon a collection of very definite factors. In essence, the steel is bought by an investor, who does some careful figuring. He estimates what the property will return in annual earnings, and makes allowance for amortization. He considers the cost of the steel, the cost of the other materials that must be used at the same time, and the cost of the labor necessary to convert the steel and other materials into the final work. Then he checks up the whole matter by estimating how much the same thing would cost one year or two years hence. If a saving in first cost is shown, that has its own value, and there is coupled with it the fact that one year or two years hence the investor will have clearer vision as to the future earning power of the investment.

As to steel demand in the remainder of the world, the comparison between the American and foreign industries is favorable in one respect and unfavorable in another. Taking the American steel industry as representing 50,000,000 tons of ingots a year, the British industry is between 20 and 25 per cent as large; the French industry, cut in half by the war, and to be reconstituted but slowly, represents not much over 5 per cent; the German industry represents between 15 and 20 per cent, and the Belgian industry is practically destroyed. The total is hardly more than 40 per cent, apart from capacity in Canada, Japan, India, Italy, etc. If the world wants much steel it must come to the United States, and in that respect the alignment is very favorable. On the other hand, the production of the whole world before the war, excluding the United States, was less than 44,000,000 tons of ingots. Including material received from the United States the world got along with an amount of steel less than the present capacity of the United States. It was not a prodigal user of steel as the United States has been, and in that respect the comparison between steel capacity in this country and conditions outside this country is unfavorable.

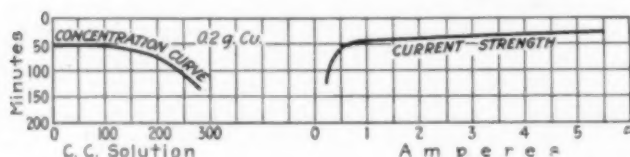
Readers' Views and Comments

Rapid Electrolytic Copper Assay Without Rotating Cathode

To the Editor of Chemical & Metallurgical Engineering

SIR:—Nearly all apparatus for electrolytic analysis on the market is equipped with a motor and revolving cathodes. This enables the agitating of the electrolyte while the metal is being deposited, and is a distinct advantage. The solution is stirred and fresh copper ions come in contact with the electrode continually. Also any hydrogen bubbles formed on the cathode are broken by the agitation, thus eliminating the danger of spongy copper being formed. Moreover, under these conditions, a very much higher current density can be used than otherwise would be possible and instead of leaving your assay over night you have it done in a few minutes.

However, even without this elaborate equipment it is possible to perform this assay quickly if precisely the proper conditions are obtained. As chief chemist



for the Vermont Copper Co., at South Strafford, Vermont, I conducted a number of experiments along this line and the following was found to be the best method of procedure.

A sample on the ore was decomposed in 5 cc. each of HNO_3 and HCl , heated nearly to dryness, and then 5 cc. of H_2SO_4 was added and heat applied until SO_2 fumes were freely evolved. The residue was cooled, diluted, 1 cc. of HNO_3 added to break up the anhydrous ferrous sulphate, boiled, cooled and filtered to remove insoluble. The filtrate was then placed under the electrodes and the copper precipitated. After precipitation the cathode was washed in water and then in alcohol, and then burned over a free flame before weighing.

The Winkler type of cathode was used, which in this case was constructed of a cylinder of platinum gauze 3 cm. in diameter and 6 cm. in length. The gauze was composed of wires 0.06 mm. in diameter with forty-one meshes per linear centimeter. The anode used was simply a spiral of No. 16 platinum wire hung inside the cathode. With this arrangement rapid deposition was effected and no trouble with spongy deposits was encountered.

Another fact that facilitated rapid work was the quantity of solution used. The accompanying graph shows the result of a series of experiments. However, I found 100 cc. to be the minimum amount of solution I could use without having the solution so concentrated that it would dissolve up the copper faster than it was precipitated.

The other graph shows the result of varying the current strength. I believe the conclusions are self-evident.

The cost of making assays by this method was 30c. each. This figure includes cost of materials, labor, interest on cost of laboratory equipment, and depreciation.

RICHARD G. PLACE.

Acme Manganese Mining Co.,
Pasadena, Calif.

The Perchloric Acid Method for Potash in Cement Materials

To the Editor of Chemical & Metallurgical Engineering

SIR:—Since the almost prohibitive cost of platinum salts has made the determination of potash by the old method quite an expense to those who, like the cement chemists of to-day, have frequent occasion to determine K_2O , analysts have turned to other methods which may be substituted for that employing platinic chloride, and two are in common use, the cobalti-nitrite and the perchloric acid methods.

The former is held by many authorities to be unreliable and is also somewhat complicated, though it is capable of giving excellent results if carefully performed, but the perchloric acid method has lately sprung into prominence through the possibility of obtaining perchloric acid (60 per cent solution) in pure form at a reasonable price.

The manufacturers of this acid give directions for its use in potash determinations which are satisfactory as regards water-soluble potash, but they say nothing of the *modus operandi* when total potash is required, as it often is in such materials as shale, clay, flue dust, etc., which, being silicates in whole or part, require fusion before they can be brought into solution.

The writer has found that the determination of water-soluble potash by the perchloric acid method is simple, rapid and accurate. The substance is boiled half an hour with excess of water, filtered, and the filtrate acidified with HCl . Sulphates are precipitated as BaSO_4 and removed by filtration, and calcium is precipitated in the filtrate by ammonium carbonate and a little ammonium oxalate. These reagents are both volatile at a low heat, so that when the filtrate from the carbonate precipitate is evaporated and the residue moderately heated, ammonium salts pass off, leaving nothing remaining but chlorides of potash and soda. These salts are converted into perchlorates by a little perchloric acid and separated by alcohol, which dissolves the sodium perchlorate, but leaves the potassium perchlorate undissolved, and the latter can be readily collected on an asbestos filter and weighed.

The treatment of flue dust, etc., for total potash is necessarily more complex, but presents no difficulties. Of course, ordinary fusion with carbonates to break up the silicates is not permissible, as this would introduce large proportions of soda and probably some potash, which would obscure the result, so it is best to adhere to the J. Lawrence Smith fusion with ammonium chloride and calcium carbonate preferably in a long platinum crucible. After digestion of the charge in water the excess calcium carbonate is filtered off, the filtrate acidified with HCl and treated exactly as the first filtrate in the water-soluble determination.

The writer has found that most flue dust contains

organic matter which necessitates filtration after driving off the ammonia salts by heat, that is, before evaporating the solution of sodium and potassium chlorides with perchloric acid. Otherwise the operations for total and water-soluble potash are identical after the first solution is obtained. In detail the method employed in our laboratories is as follows:

For Total Potash. Grind $\frac{1}{2}$ g. of the sample (flue dust, shale, etc.) with $\frac{1}{2}$ g. ammonium chloride in an agate mortar. Add 4 g. of pure calcium carbonate and grind thoroughly together. Put a little calcium carbonate in bottom of J. Lawrence Smith crucible, add the charge with 1 g. calcium carbonate on top, cover and heat with a low flame till there is no further odor of ammonia (15 min.). The heat must not be high enough to permit the escape of visible fumes. Then raise the heat to moderate redness for 45 min., turning crucible occasionally. Cool, dissolve the melt in a little water, carefully rinsing the crucible. Slake on water bath, breaking up lumps. Filter off excess calcium carbonate, wash and make filtrate strongly acid with HCl. Boil and add slight excess of barium chloride. Let stand preferably several hours. Filter off the barium sulphate, wash, heat the filtrate to boiling and add ammonia till alkaline, and ammonium carbonate until no further precipitate forms. Add a few drops of ammonium oxalate, filter and wash. Evaporate the filtrate to dryness in a platinum dish and when dry heat carefully to just below redness till all ammonium chloride fumes are gone. Cool, dissolve in 25 cc. hot water, filter off anything undissolved and add to the filtrate enough 60 per cent perchloric acid solution to convert all the alkali metals into perchlorates (ordinarily 1 cc. is enough). Evaporate until nearly dry and when heavy fumes of HClO_4 appear cool, add 25 cc. hot water, another cc. perchloric acid and evaporate again to the same point. Cool, add 25 cc. wash alcohol (containing 1 cc. perchloric acid solution to every 300 cc.), filter on asbestos in a Gooch crucible, wash with the same alcohol, dry and weigh as KClO_4 .

In washing the precipitates it is unnecessary to wash them entirely chlorine free; for ordinary work three or four washings are sufficient. The barium chloride, ammonium carbonate and ammonium oxalate mentioned are all used in saturated solutions.

For Water-Soluble Potash. Five grams of the sample are boiled 30 min. with 150 cc. water in a small flask with condensing tube. Cool. Make up to 250 cc., mix well and filter through a dry paper without washing. Take 50 cc. of the filtrate, corresponding to 1 g. of the sample, acidify strongly with HCl and proceed as in the determination of total potash given above. Multiply weight of potassium perchlorate found by 33.935 for per cent of K_2O in sample. WILLIAM B. NEWBERRY.

Sandusky Cement Co.,
Cleveland, Ohio.

Credit to Whom Credit Is Due

To the Editor of Chemical & Metallurgical Engineering

SIR:—I read, with great interest, an article in your issue of April 15 by the Messrs. H. E. and C. E. Hollister regarding the great acid plants of the Government powder plant, and it seems to me as if everybody comes in for some mention for his particular part in this great undertaking, from the lowly shoveler to the superintendent. But there is one branch with which I had the pleasure of being connected and which I

know put forth its best efforts in connection with this work and seems to have been completely ignored. This branch was the resident engineers' department of the Thompson-Starrett Co. under Mr. A. E. Barlow, who supervised the entire field work of the areas mentioned in your article, and labored from sunrise to sunset, rain or shine, to lay out the work so that construction could be carried on. Mr. Geo. Uhden was the engineer directly in charge of Area "B" and Mr. Fred Petzold in Area "C."

In justice to the above-mentioned branch of the organization and its members I think this letter should receive as much publicity through your columns as the article which so completely ignored them.

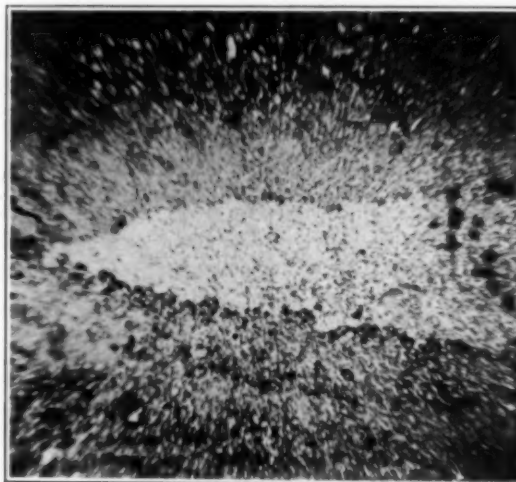
Brooklyn, N. Y.

FRED PETZOLD.

Flakes in Steel

To the Editor of Chemical & Metallurgical Engineering

SIR:—In my paper on Flakes in Steel in your April 1 issue a correction should be made. On page 351 the phrase on line 34 from the top reads: "Another possible cause for flake may be segregated spots such as are exhibited by the variable-hued grains in Fig. 23."



This is wrong. The expression refers to a picture which was not reproduced and of which I enclose a copy. The variable hued grains in Fig. 23 do not, in my opinion, cause flakes. Fig. 25 shows the same kind of differently hued grains and is from a bar practically free from sign of flake.

HAAKON STYRI.

Carnegie Institute of Technology,
Pittsburgh, Pa.

Bids Requested on Chlorine

Sealed proposals in duplicate addressed to Paints Branch, Raw Materials Division, Munitions Bldg., Washington, D. C., are desired on 6500 lb. of liquid chlorine, bidders to specify size of container and quote price f.o.b. Camp Merritt, N. J.

Standard Form for Mexican Claims

The State Department at Washington announces that a standard form has been prepared for filing claims against the Mexican Government. It is expected that the final form will be prepared for approval by the middle of May, at which time copies will be sent to those who have claims in order that they may be resubmitted. The new form will supersede all previous ones.

Western Chemical and Metallurgical Field

Cost of Quicksilver and Fulminate

ANY attempt to estimate the cost of metal production is likely to be misleading, since conditions vary so much from district to district, while even with identical mining and metallurgical practice and efficiency, the cost per unit varies immensely with the tenor of the ore. F. C. Ransome, in a recently issued Geological Survey publication on quicksilver, has estimated the labor required to produce mercury in American mines during 1917 as follows:

RELATIONS OF QUICKSILVER PRODUCTION TO LABOR IN CALIFORNIA AND TEXAS

	California		Texas, Three Mines
	All Mines	Eight Leading Mines	
Ore treated, short tons	235,786	203,449	26,802
Quicksilver produced, flasks	23,938	18,581	10,530
Tenor won	0.38	0.34	1.47
Average number of men employed	950	715	253
Man-days of work	310,500	233,689	84,795
Quantity of ore treated per man, short tons	248.1	322.8	105.9
Quantity of ore treated per man-day, short tons	0.75	0.99	0.32
Quicksilver obtained per man annually, flasks	25.1	26.0	41.6
Quicksilver obtained per man-day, flasks	0.077	0.079	0.124

On this basis he estimates that in 1917 the average cost, including development and amortization, of producing a 75-lb. flask of mercury in California from 0.38 per cent ore was from \$65 to \$70. The cost in Texas was lower, due to its average content of 1.43 per cent. Spanish mines in Almaden made \$12 quicksilver from 9.04 per cent ore in 1915. Monte Amiata in Italy produced mercury for about \$30 in 1913 from 0.89 per cent ore, while the pre-war cost at Idria, Austria, was \$23 per flask from 0.65 per cent ore.

While the foregoing figures are as of 1917, it is entirely safe to assume that costs of production in California and Texas have not dropped in the meantime, so with the present San Francisco price of \$70 per flask it is easy to understand the closure of some California quicksilver mines and the curtailment of operations of others. During the war the developed ore reserves and ore dump were nearly exhausted. Mexican importations amounted to about 250 flasks in February of this year. While unrestricted competition with Mexican and Spanish mercury would make the continuance of the American industry dubious, material importations from Mexico are contingent upon stabilization of their uncertain internal affairs, while shipping capacity is still so largely engaged in post-war activities that large quantities of European metal may not arrive for some months.

As noted in our issue for Sept. 1, 1918 (p. 240), about one-third the American production and consumption is absorbed in drugs, chemicals and dental amalgams. An equal part was expected to be used by the ordnance departments for fulminate— $\text{Hg}(\text{CNO})_2$ —in detonating high explosives. Owing to the high cost and scarcity of mercury and the tremendously expanded use of fulminate, many efforts were made to substitute other compounds in whole or in part. This was only partially successful, however, owing somewhat to the uncertainty of action of the substitutes, and their high cost. In other words, during 1918 a prominent detonator manufacturer stated that straight fulminate from \$100 mercury was probably cheaper than the then available substitutes. Fulminate is often combined with

other substances, particularly with an abrasive, such as powdered glass, to increase its sensitiveness, and with compounds or mixtures that themselves have the property of detonating, such as sulphide of antimony and chlorate of potassium. Recently a large part of the mercury fulminate in detonators has been replaced by picric acid, trinitrotoluene, or tetranitromethylamine, according to Walter Arthur, whereby a much stronger initial effect is obtained and one part of mercury fulminate is made to detonate a charge that would have required six times as much fulminate used alone. Other substances have been found also which seem likely to replace mercury fulminate entirely for certain uses. One of these is lead azide, a salt of hydronitric acid. Large dry crystals of this salt are so sensitive as to explode when brushed with a feather, but smaller crystals are less sensitive. Other proposed substitutes are lead styphnate, $\text{PbC}(\text{NO}_3)_3$; hexamethylamine triperoxidediamine, $\text{N}(\text{CH}_2\text{O.OH})_3\text{N}$, said to be four or five times as strong as mercury fulminate; nitrogen tetrasulphide, N_2S_4 ; diazobenzonitrate, $\text{C}_6\text{H}_5\text{N}_2(\text{NO}_3)$; basic mercury nitromethane; and perchlorate of trimercuraldehyde.

Minerals Relief Commission

The organization of the commission for the settlement of the net losses sustained by the producers of manganese, chromium, pyrite and tungsten has been completed. The members of the commission are John F. Shafroth, Chairman; M. D. Foster and Philip N. Moore. The commission's headquarters is Room 2131, Interior Department Building, Washington, D. C. Under the procedure established by the commission a questionnaire is sent out to the claimant, and when this questionnaire is returned, the facts which it presents form the basis for determining what further examination of the claim is warranted. The verification of facts and the field examination of mines is being carried out by the Bureau of Mines, when such examination is requested by the commission, but the commission has entire authority in making awards.

Vancouver Conference

A well-attended conference of Western mining men was held in Vancouver, B. C., during March, at which some interesting discussions were held. At the end all the members were urged to lend their efforts toward the initiation and support of a modest iron and steel industry near the international boundary, Prof. Stansfield having reported the venture as metallurgically feasible, and Minister of Mines Sloan having declared that British Columbia possessed the ore in proper quantity and quality.

A resolution interesting to metallurgists was adopted, calling for the abolishment of the fixed price for silver. From the producer's standpoint, fixed prices sometimes appear good and sometimes bad—American farmers, for instance, do not seem to resent the fixed price for wheat. On the other hand, most of the men present at the Vancouver conference were sure that in a free market the price of silver would advance to at least \$1.20 per oz., due to the demands for coinage to replace the metal hoarded by subjects of Eastern governments which are in various stages of instability.

Sydney Norman, Editor of *Northwest Mining Truth*, in a plea for government control of smelters, called attention to the absence of cordial relations between

smelters and miners which appears everywhere, and which has been subject of comment for years. The smelters contend that their rates are as low as good business will permit, while the miners feel they are not getting a fair share of the returns. The speaker argued that if the rates really are correct, the smelters should not object to an impartial regulation, especially since it would remove that popular discontent and distrust which leads to a demand for outright government ownership. He also declared that in return for such regulation the British Columbian government would be justified in subsidizing the operation of a tide-water smelter and refinery to such an extent as would be necessary to insure a good volume of ore supply.

Copper Production and Price

An editorial in *CHEMICAL & METALLURGICAL ENGINEERING* for Feb. 15, 1919, noted the fact that wages in copper mines, mills and smelters were generally reduced on Feb. 1, to correspond approximately with the declining metal market. A number of minor labor disturbances followed, which were fortunately of short duration—even a well-advertised I. W. W. demonstration in Butte being only a flash in the pan. The steadier heads among copper operatives realized that this is only another trough in the fluctuations in the copper world, and have learned to accept, with considerable equanimity, these recurrences of slack times.

The present rate of production is rather hard to estimate. Ten large properties in February hoisted 65 per cent of their output for the preceding October. These companies have accumulated a considerable cash reserve and are able to finance a large unsold stock, while their costs, when sheared of such items as depreciation and depletion allowed on income tax returns, are still at or below the present market price.

Many smaller producers, whose aggregate output is very considerable, are not so well circumstanced, however, and have shut down entirely, or are merely holding a skeleton crew on repairs and development.

Supposing the total U. S. smelter production at the present writing to be but 50 per cent that of the 1918 rate, it would amount to 955,000,000 lb. per year, which is still equal to 83 per cent of the production of 1914 (a rather slack year). Bearing in mind the accumulated stocks of copper on hand of over a billion pounds which must be absorbed, the dislocation of industry and its impaired buying power, and the present greatly reduced export demand, it is apparent that courageous convictions as to the near future must be held by the leaders of the copper industry.

In view of the "buy now—never mind the price" propaganda of American industries in general, it is refreshing to view the old-fashioned methods used by copper men to stimulate demand. They had large quantities to sell and used the best and most reasonable method—they cut the price to a point where purchasers who needed it became interested. Buying at 14½ to 15c. was so well sustained that a moderate rise in price has since been recorded, visible stocks for sale are at least not growing, and any intending purchasers of the red metal do not need a "price guarantee." Were the inflated prices of foodstuffs, clothing, steel products, manufactured articles and other necessities of private and industrial life to approach pre-war normals with as little disturbance to labor rates as have the copper quotations, industrial activity and expansion would have its biggest obstacle removed.

Symposium on Pyrometry at Fall Meeting of A. I. M. E.

ONE of the features of the meeting of the American Institute of Mining and Metallurgical Engineering to be held in Chicago next September is a symposium on pyrometry which is being prepared by a special committee of which Paul D. Foote, Bureau of Standards, Washington, D. C., is secretary. Thus far 20 papers have been promised. The program of the symposium will have the following scope:

- I. Methods of pyrometry.
 1. Thermo-electric pyrometry.
 2. Resistance thermometry.
 3. Optical and radiation pyrometry.
 4. Seger cones and veritas firing rings, etc.
 5. Standardization and testing of pyrometers.
 6. Recording pyrometry.
 7. Automatic, semi-automatic and manual signal and temperature control.
- II. Industrial pyrometry.
 1. Pyrometry in the metallurgical industries.
 - (a) Pyrometry and steel manufacture.
 - (b) Heat treatment and forging of steel.
 - (c) Pyrometry in the non-ferrous foundry.
 - (d) Pyrometry and industrial heating furnaces.
 2. Pyrometry in the chemical industries.
 3. Pyrometry in the ceramic industries.
 - (a) Pyrometer porcelains and refractories.
 4. Pyrometry and glass manufacture.
 - (a) Plate glass.
 - (b) Bottle glass and general chemical glassware.
 - (c) Optical glass.
 5. Pyrometry and gas manufacture.
 6. Pyrometry and coke manufacture.
- III. Pyrometry and its relation to science.
 1. High temperature scale.
 2. Melting points of metals and refractories.
 3. Precision optical pyrometry.
 4. Optical pyrometry and illuminating engineering.
 5. Fundamental constants of pyrometry.
 6. The teaching of pyrometry in our technical schools.

Use for Surplus TNT

All surplus TNT and other explosives owned by the War Department which can be used in clearing land, building roads, general construction work or in any way as a substitute for the ordinary commercial dynamite have been turned over to the Department of Interior. These explosives will be used on public works, and a portion may be used for the clearing of lands for honorably discharged soldiers, provided a soldiers' settlement bill is passed by the next Congress. This material, which at one time was considered practically worthless, now has an estimated value of \$15,000,000. There will be no public sale of explosives by the Army, and if any surplus of this material is found in the future, it is thought that it can be used by the Department of Interior.

Imports of Tungsten-Bearing Ore

The Division of Statistics, Bureau of Foreign and Domestic Commerce, of the United States Department of Commerce reports the following imports of tungsten-bearing ore and exports of tungsten and ferro-tungsten metal for February, 1919:

IMPORTS OF TUNGSTEN-BEARING ORE, BY COUNTRIES, AND EXPORTS OF TUNGSTEN AND FERRO-TUNGSTEN METAL, BY COUNTRIES

Imports			Exports		
Countries	Tons	Value	Countries	Tons	Value
Panama.....	0	\$172	Japan.....	451	\$645,886
Bolivia.....	14	9,984			
Chile.....	63	88,080	Total.....	1,535	\$1,810,864
Peru.....	60	62,752			
China.....	424	442,626			
Chosen.....	46	58,375	Countries	Pounds	Value
Hongkong.....	477	502,989	Canada.....	30	\$137

Import License Proposed

SPEAKING before the National Cotton Manufacturers' Association on April 25, Francis P. Garvan, Alien Property Custodian, declaring that it is necessary that Congress adopt an import license system, said:

"The Chemical Foundation proposes to place all possible information on our situation before Congress, and ask the passage of a law establishing a license system governing all chemical importations for a period of ten years. It is intended that this license system shall act at one and the same time as a guarantee to you and all other dependent industries proper importations to enable you to meet the competition of other lands, and to protect and guard our growing chemical independence. In this we ask no more than England, France, Italy and Japan already have decided to grant on behalf of their own independence. This request we base upon the following grounds:

1. Fairness to the \$500,000,000 invested by loyal Americans in the hour of our need.
2. Independence and freedom of the textile, leather, paper, paint and varnish, pharmaceutical \$3,000,000,000 essential American business.
3. The necessity of our national defense.
4. The destruction and prevention of the German system of propaganda and espionage in our land.
5. The advancement of pure science and research.
6. The advancement of medical science.

"The granting of this license system is not a question of conflicting economic schools. It is the question of our national independence, safety and education.

"Once we are assured time in which to work out our salvation we hope to turn to our dearest objective. Already we have started to make a survey of our laboratory equipment—governmental, university and factory. Already company after company has passed resolutions through their boards of directors placing at the disposal of our trustees, under such terms and conditions as those trustees may dictate, their entire research capacity. Government laboratories and university laboratories also have been assured us. Gentlemen, we know that offer will be unanimous.

"We soon will be able to go to the medical profession of America and offer to them the entire capacity of the country for experiment and research for the betterment of mankind. One medical chemist in one dye factory in Germany discovered the cure for syphilis, the deadliest enemy of mankind. The same medical chemist, in the same dye factory, discovered the cure for the sleeping sickness of Africa which made a continent habitable. What can we not hope for when the American medical profession is given unbounded scope and opportunity?

"We are assured that somewhere within that realm lies the hope of the cure for consumption, cancer and many of the seizures which rob us of our little ones. Can it be that herein lies the opportunity of converting the forces which up to now have been directed only toward desolation and destruction into the channels of alleviation and helpfulness to humanity? Can it be that through this medium idealist America may snatch the torch of misapplied science from the barbarian, and place it in the hands of an enlightened civilization?

"Gentlemen, Drs. Albert and Bernstorff reported to their government that America never could establish the dye and pharmaceutical industry in this country, as we lacked the moral power for the creation of such an industry, that here each party pursued its own selfish interests, but nobody kept the whole in mind; that this

problem could be solved only through regard for all points of view, and that the conflicting selfishness of this country rendered that solution impossible.

"The Chemical Foundation answers this statement with a challenge, and if it can become only the co-ordinating forum for American patriotism, American sacrifice and American ability, it awaits the issue with serenity."

Merck Stock to Be Auctioned

There will be a sale of 8,000 shares of the capital stock of Merck & Co., drug and chemical manufacturers, to the highest bidder at public auction at 11 a. m., Friday, May 9, when the shares in question will be offered by the Alien Property Custodian, Francis P. Garvan, who has possession of them by virtue of their having been delivered to him voluntarily by Mr. Merck in order that the question of their ultimate ownership might be settled. The shares represent 80 per cent of the total authorized and outstanding issue of 10,000 shares of capital stock having a par value of \$100 each.

The company has its principal administrative offices at 45 Park place, New York City, where the bids will be received by Mr. Joseph F. Guffey, Director of Sales, A. P. C. office, and branch offices at St. Louis, Mo., and Montreal, Canada. Its principal plant is at Rahway, N. J., where 150 acres of land are occupied by the various buildings, the total area under roof being placed at 20 acres. This plant has been greatly enlarged since 1914. The company also has a small plant at Midland, Mich., within the Dow Works.

The New Jersey Chemical Society Spring Meeting

The New Jersey Chemical Society will hold its Spring invitation meeting in the Chemical Building, Rutgers College, New Brunswick, N. J., Saturday, May 10, 1919. Dinner will be served in the University dining hall at 7 p.m.

The program for the evening includes: "Address of Welcome," by Dr. W. H. S. Demarest, president of Rutgers College; "Stability of Automobile Engine Oils," by J. V. Meigs of Montclair, N. J.; "Oxidation and Reduction," with demonstrations, by Ernest Little, professor of chemistry; "Chemical Reactions Among the Lower Animals Causing Evolution of New Species," with stereopticon views, by Daniel R. Hodgdon, director of the Newark Technical College, Newark, N. J.

Information concerning membership and invitations for the Spring meeting in May can be obtained from Mr. H. C. Cawley, secretary, 256 Vanderpool St., Newark, N. J.

American Bureau of Welding

At a meeting of the American Bureau of Welding held on April 11, at the Engineering Societies Building, 33 West 39th St., New York, the by-laws of the bureau were adopted and the following officers elected:

Director, C. A. Adams; vice-director, H. M. Hobart; vice-director, A. S. Kinsey; treasurer, W. E. Symons; secretary, H. C. Forbes.

Regular meetings of the Bureau are to be held on the third Friday of each month.

The Bureau voted to establish a Research Committee for the purpose of carrying out the plan of co-operation in conducting investigations in welding.

A committee of 52 members has been appointed.

"Hamlet" With Hamlet Left Out

THE New York Section of the Society of Chemical Industry had a meeting of unusual interest on April 18, by making the most of what threatened to be a disappointment. The paper for the evening was announced as by two authors of eminent authority whose names are well known as a guaranty of scholarship and sound practice. Preceding the paper was the presentation of two portraits to the Chemists' Club in the hall of which the meeting was held. In the absence of Major Charles E. Sholes, the honorary chairman, Dr. Parker C. McIlhiney presided, and after a short delay the meeting began. The delay was caused by the absence of both the authors of the paper of the evening, whose arrival was expected every minute. After the usual preliminaries Dr. McIlhiney called upon Dr. W. H. Nichols, president of the American Chemical Society, to make the presentation on behalf of the General Chemical Co. and the Nichols Copper Co. of the portrait of Mr. J. B. Francis Herreshoff, who received the first Perkin Medal eleven years ago.¹ He told of his start fifty years ago in the chemical business, making 66 deg. B. sulphuric acid at Laurel Hill, of his partner Mr. Walter, and their one hired man who constituted the proletariat.

At this time the petroleum refiners began to use large quantities of 66 deg. acid for the clarification of oil. It was due to the ability of Dr. Nichols' works to make dependable delivery at this concentration and not just approach the neighborhood of 65 deg. or thereabouts that the first great acid market—that of the ever growing American petroleum industry—was secured for the coming General Chemical Co. An important commercial feature, which was first observed by Mr. Herreshoff, was that acid which had been concentrated to 66 deg. could be shipped in steel drums or tank cars.

Up to his untimely death at sea while en route to Germany, Mr. Walter had been the business man, and Mr. Nichols the scientist. It now became Mr. Nichols' province to attend to the firm's business affairs, and when young Herreshoff, who, though a sophomore, had been teaching seniors chemistry at Brown University, applied for a position, he took him on. They were all young except the hired man and the competitors, and of the latter a number of kindly elder men cautioned young manager Nichols against the danger of taking such a theorist, fresh from teaching in a college, into his factory. He would surely live to rue the day, they said. Dr. Nichols confessed to a certain measure of stubbornness in the matter, with the result that the same theorist and he have been working together ever since. At this point he admitted that he was talking against time, in the hope of seeing the appearance of one of the authors of the paper on the program; but neither arrived.

Then followed reminiscences in connection with making sulphuric acid and another enterprise that was also certain, according to the advice of practical men, to end in ruin. This was no less than the purchase of a copper mine with sulphur-bearing ore which nobody else wanted. When Herreshoff had mastered the roasting problem, they thought they had a good thing, and saw no reason why they might not turn an honest penny by royalties; but again they were scorned for their youth and inexperience in the metallurgical methods of

the day by the old timers both here and abroad. Then followed intimate details of technical problems and business turns, as romantic as any knights' adventures; the beginning of the electrolytic refining of copper, the reason why they were driven to it in order to maintain their independence, the quick response of Herreshoff in shifting laboratory scale operations to meet plant requirements and the organization of the Nichols Copper Co., all worth a long journey to hear.

Professor Chandler followed, presenting on behalf of Mrs. Acheson a portrait of her husband, Dr. E. G. Acheson, Perkin Medalist for 1910², and here again was a good story. There was the beginning with Thomas A. Edison and his work on the carbon filament, and finally Dr. Acheson's independent work resulting in carborundum and artificial graphite. It was a neatly turned biography with romance in it, all presented in Dr. Chandler's happiest style.

President Hendrick on behalf of the club received with a few remarks the two portraits that had just been unveiled by the previous speakers—but it was not given to him to kill time. Owing to the provisions of the constitution and by-laws of the club and the approaching annual meeting, there was a trustees' meeting called for the same evening, and it behooved them to convene in their room to get through with certain measures of important business.

It was still, however, merely the shank of the evening, but a little after 9 o'clock; and Chairman Dr. McIlhiney had his audience, but nobody to present a leading paper. So he called on Dr. Herreshoff, who reviewed in an intimate and informal manner many of the vicissitudes which he had met along the way, and after he had finished Dr. Acheson, who is ordinarily as shy as a girl about talking in public, was induced to take the platform, and he told his experiences with the same freedom as his predecessors.

At seventeen years of age, Mr. Acheson decided to become a chemist. His father had a small foundry near Pittsburgh and sent samples of coke and iron there to the laboratory of Otto Wood for analysis more or less regularly. Feeling that a very practical way to get a chemical education would be through Wood, young Acheson went to Pittsburgh filled with great hopes for his future. To his surprise, Wood's advice was "Don't become a chemist. It's a humdrum life with no prospects, etc." Undoubtedly it is fortunate for so keen a mind as that possessed by our inventor of electrothermal products of the carbosilicon series that he drifted around until he landed in Mr. Edison's keeping at Menlo Park. The subsequent events³ are too well known to our readers to be described here in detail. Mr. Acheson mentioned his present research on colloidal deflocculation with graphite and clay. He has been able to produce perfectly translucent solutions of these materials, which are so finely divided that they have excited the admiration of the foremost ultramicroscope investigators.

It was just as though those present had been sitting in the club about a cosy fire, while W. H. Nichols, J. B. F. Herreshoff and E. G. Acheson had each opened up, and told, as among friends, his experiences in applied chemistry, with a delightful little talk by the fine old dean of American chemists added to it. It was a memorable occasion.

¹Electrochemical and Metallurgical Industry, Feb., 1908, Vol. VI, p. 51.

²METALLURGICAL & CHEMICAL ENGINEERING, Feb., 1910, Vol. VIII, p. 69.

³Electrochemical Industry, Vol. I, p. 90, Nov., 1902.

Metallic Coatings for Rust-Proofing Iron and Steel—I

A Concise Account of the Nature of Corrosion, Rust-Proofing Metal Coatings, With Recommendations, Is Given—Description and Comparative Values of Different Methods of Testing Coatings, Especially of Zinc

By HENRY S. RAWDON,¹ M. A. GROSSMAN²
AND A. N. FINN³

THE study of the deterioration of iron and steel, particularly by corrosion, and the means for mitigating the same, has probably received more attention, and properly so, than any other phase in the study of steel. In the following article, the experimental results, when given, have been taken from the results of the numerous examinations and tests of materials submitted to the Bureau of Standards during the past few years. The general and more descriptive portions have been summarized after a careful review of the most helpful articles in the literature on the subject of corrosion, which is extremely voluminous.

I. INTRODUCTION

1. GENERAL NATURE OF CORROSION

Various theories have been advanced concerning the nature of the process of the corrosion of iron, and a vast amount of experimental work has been done to support these theories. All agree, however, that the process is electrolytic in its nature, and the various hypotheses differ only as to the factors by which the electrolytic action is brought about. Iron and steel will not corrode in dry air—the presence of moisture is an essential condition, and according to one of the theories, carbon dioxide must also be present. Protection from atmospheric corrosion may be afforded in two ways; first, by mechanically excluding all moisture and other corroding agents from the iron and steel, and, second, by using coatings of such a chemical nature that the covering itself is corroded in preference to the iron or steel beneath. It must be remembered that all "rust-proofing processes" are temporary only in character; some, however, are so far superior to others that the use of the term "rust-proofed" is justifiable in such cases.

The attempt to prolong the life of iron and steel parts in service by protecting them against corrosion has led to the adoption of many materials and processes for coating. The protective materials fall in general into three classes: (1) The metallic coatings, (2) the coatings in which the iron to be protected is itself converted at the surface into some less corrodible compound, and (3) the organic coatings, including paints, varnishes, enamels, etc. The metallic coatings include all the common metals and alloys that can be applied at all readily to steel, namely, zinc and aluminium, which are electro-positive to iron (as explained below), and tin, lead, "terne" and other lead alloys, copper, nickel, cobalt, brass, bronze and silver, all of which are electro-negative to iron. In the case of the iron compounds, the iron at the surface is converted to oxide or to some other compound and the piece is then

usually given an oil finish. The organic coatings will not be discussed in this article.

2. PRINCIPLES UNDERLYING METHODS OF PREVENTION

Of the metallic coatings, the best, by far, for general rust-proofing is zinc. The principal reason for this lies in the chemical nature of zinc—it is the only one of the commonly used metals that is electro-positive to iron, that is, it has a greater tendency to be oxidized than has iron. In the following table the metallic elements are arranged in their proper order in the potential series. Any element is electro-positive to any element following and electro-negative to any element preceding it in the table:

POTENTIAL SERIES					
K	Potassium	Fe	Iron	Cu	Copper
Na	Sodium	Cd	Cadmium	As	Arsenic
Ba	Barium	Tl	Thallium	Bi	Bismuth
Sr	Strontium	Co	Cobalt	Sb	Antimony
Ca	Calcium	Ni	Nickel	Hg	Mercury
Mg	Magnesium	Sn	Tin	Ag	Silver
Al	Aluminium	Pb	Lead	Pt	Platinum
Mn	Manganese	H	Hydrogen	Au	Gold
Zn	Zinc				

When any steel article with a metallic coating is scratched or abraded so that a small area of the steel is exposed, the two dissimilar metals together with a small amount of moisture derived from the atmosphere will form a tiny galvanic cell, set up a current and start corrosion. That metal which is electro-positive to the other will be the one to be oxidized, while the electro-negative metal will remain uncorroded. So if the coating metal is zinc, it is zinc that will be oxidized, while the iron remains bright and uncorroded until the "bare" spot becomes so large that the central portion is beyond the "protective zone" of the surrounding zinc. On the other hand, should the coating happen to be tin, which is electro-negative to iron, it would be the steel that would suffer. In such a case, the tin coating is actually injurious, because without it the steel would oxidize at the normal rate, with no galvanic action to hasten the corrosion. The value of tin for coatings depends upon other factors than its electrochemical nature.

Zinc, then, has the advantage of being electro-positive to iron and so preventing its corrosion, especially on small exposed areas such as "pin-holes" in the coating, scratches, etc. One other common metal, aluminium, is also electro-positive to iron, but does not share the other advantages enjoyed by zinc, such as relatively low cost, the ease with which it can be applied to steel in quite a number of ways, and the fact that with a little care it will solder readily. (Refs. 1-11 inc.)

II. TYPES OF COATINGS AND METHODS OF APPLICATION

1. METALLIC COATINGS

a. *Zinc.* The oldest process for zincing or galvanizing, and the one most widely used, is the hot-dipping process, in which the steel, after a preliminary cleaning

¹Asso. Physicist (Metallography), Bur. of Standards.

²Metallographist, Vanadium Co. of America.

³Asso. Chemist, Bur. of Standards.

of the surface, is immersed in molten zinc, left in the bath long enough for the steel to reach the temperature of the zinc and then withdrawn with the coating of zinc adhering to it (24, 25, 26, 27). It is a simple process and gives excellent results on smooth surfaces. In general, a piece of steel that has been zinc-coated by the proper hot-dipping method will be well protected against corrosion even under severe conditions of exposure.

SHERARDIZING

Another method of zincing, called sherardizing, consists in heating the steel in a so-called "zinc vapor" atmosphere. The steel parts are packed in a revolving drum with zinc dust containing a small amount of zinc oxide, and heated at 350 to 375 deg. C. (28, 29, 30, 31, 32, 33, 34). The cylinder is made to rotate slowly on its axis to tumble the parts and insure evenness of coating. Usually $3\frac{1}{2}$ to 4 hours' heating is required to produce a satisfactory coating.

Zinc is also applied to steel by plating from an aqueous solution (36, 37, 38, 39, 40). Those commonly used are either a solution of zinc sulphate containing a small amount of free acid or a solution of zinc cyanide or one of zinc oxide in a mixture of sodium cyanide and sodium hydroxide. The plating usually takes from a half-hour to an hour, but may be continued longer to produce very heavy deposits.

There are other methods of applying zinc which are used less often. The Schoop spray gun, for example, is a device for spraying molten metal upon an article to be coated (41, 42, 43, 44). The zinc, in the form of wire, is fed into the spray gun, where an oxy-acetylene flame melts it, and a strong current of air projects it from the nozzle in the form of a very fine spray, which is directed against the steel. In another process, called "epicassit," the zinc, in the form of filings, is mixed with a flux, made into a paste and then painted on the steel (45). The article is then heated until the zinc just melts, making a continuous adherent coating.

ADVANTAGES AND DISADVANTAGES OF EACH TYPE

Of the three forms of "zincing" most commonly used, namely, hot-dipping, sherardizing and electroplating, each type has its advantages and its disadvantages. Hot-dipping is excellent for even surfaces, as it gives a heavy coating in a very short time. The thickness of coating on such material as sheets and wires can be easily regulated by "wiping" and other mechanical devices; on irregular shaped articles, however, there is no simple way of regulating the amount of zinc used. This method cannot be used on accurately machined parts, such as screw threads, for obviously the zinc would collect in sharp corners and alter the original outlines of the piece. Neither can it be used on a highly hardened steel where the heating to 450 deg. C. (the approximate temperature of the zinc bath) would soften the steel too much for its intended use.

Sherardizing has the advantage of giving very even coatings. The coating on a screw thread, for example, will show no appreciable variation from the top to the root of the thread. On the other hand, sherardizing is a slower process, and it cannot be used on such hardened steels as would be softened too much by heating at 375 deg. C. for 3 to 4 hours. Neither is the method suited to handling large sheets, etc. Furthermore, the quality of coating produced by this method is greatly

modified by the conditions of operation, such as purity of the zinc dust, uniformity of heating, duration of treatment, so that widely different results are obtained in practice.

Electroplating has the advantage of being readily applied to small and delicate articles that are not easily handled in other ways, and the obvious advantage that it can be applied to steel without modifying any previous heat treatment. One advantage of this process is the ease of operation; there are several devices now upon the market by means of which the operation (including the preliminary cleaning and final washing) can be made a continuous one requiring but little supervision. Another distinct advantage of electroplating is the ease of control of the thickness of the deposit—within rather wide limits this is directly proportional to the period of deposition. On parts having sharp corners or depressions, however, it is apt to give uneven coatings. On threads, for example, there will be an accumulation of zinc at the top of the thread, while the root may be nearly bare, and even on flat plates it has been found that the coating is heavier at the edges than in the center. It seems probable, however, from some recent work done by this Bureau, that such differences are much less pronounced in zinc deposited from the cyanide solution than in that from the sulphate bath.

b. Aluminium. Aluminium has never been used commercially on a large scale for rust-proofing, on account of the difficulty of applying it to steel. Aluminium is electro-positive to iron, and would, therefore, make a good protective coating. One method of applying it, called "calorizing" (46, 47), is somewhat similar to sherardizing, in that the steel is packed in a mixture containing powdered aluminium and heated at 900 to 950 deg. C. This process is used commercially to a limited extent.

2. SOFT, FUSIBLE METALS (TIN, LEAD AND THEIR ALLOYS)

Almost all of the metallic coatings other than zinc and aluminium divide naturally into two classes, the soft low-melting-point ones and the hard metals with relatively high fusion points. Those in the easily fusible class, such as tin, lead and their alloys, are applied almost altogether by hot-dipping. Those not so readily fused, such as copper, nickel, cobalt, silver, brass, etc., are for the most part electroplated.

One of the most widely used of the coating metals is tin. It is in the class of metals that are electro-negative to iron, so that a tin coating must be free of pin-holes and must not be abraded or injured, or accelerated corrosion will set in where the steel base is exposed. However, the tin itself corrodes very slowly, and it has several advantages in that it is applied very easily by hot-dipping, is soldered more readily than any other coating and has the further very important advantage of having no toxic effect, so that it can be used in food-containers. Hot-dipping is used for the large majority of tinned articles, but the metal may also be applied by the Schoop spray and by plating (51, 52, 53).

Lead alloys are applied by quite the same processes as is tin, but they lack some of the advantages of tin. Lead does not solder so readily because it oxidizes quickly when heated, but it is much cheaper than tin, and has been used especially in terne, which is an alloy of about $\frac{3}{4}$ lead and $\frac{1}{4}$ tin. The electrodeposition of

lead for the production of protective coatings has recently come into commercial use. Lead, however, is electro-negative to iron and has the corresponding defects (54).

3. HARD METALS (COPPER, NICKEL, COBALT AND BRASS)

Copper has been used a great deal for rust-proofing. Metallic copper itself corrodes very slowly, and it has found such wide application largely because it is applied very readily by electroplating. But it is electro-negative to iron, so the coating must be well applied and be free of bare spots and pin-holes to protect completely against corrosion. A practice that is fairly common is the buffing of coppered parts to give a bright finish; this renders the coating more uniform in thickness and covers up such imperfections as pin-holes, etc. If the coating as deposited is very thin, however, severe buffing will remove it almost entirely in places and so accelerate corrosion.

In addition to electroplating, copper is applied with the Schoop spray gun, and by the so-called "copper-clad" process (49, 50). In the latter, copper is cast around a steel billet, and the billet rolled down to rod or sheet form. Copper so applied is less likely to be porous than is the case with electroplated or sprayed metal. The process of depositing zinc-coatings designated as "epicassit" has been modified for use in copper plating. The process is now being used industrially to a very limited extent (48).

USE OF NICKEL

Nickel is used for articles that are to have a light color, especially if a bright polish is desired. Most nickel is applied by electroplating, but it can also be applied by a process similar to the "copper-clad" process. Nickel is another one of the elements electro-negative to iron, although, being quite close to iron in the electro-chemical scale, its injurious effect is likely to be a little less pronounced.

Cobalt is quite similar to nickel in its properties, and is used in much the same way.

The electrodeposition of brass upon steel can be carried out with success and is used extensively on small articles such as builders' hardware, lighting fixtures, etc. It is plated from a solution containing both copper and zinc. It has no peculiar advantages as regards rust-proofing, but the brass color is sometimes desired. Brass has also been applied as in copper-clad and nickel-clad products, as has also bronze.

4. OXIDES AND SALTS OF IRON

a. Oxides. The oxide coatings on iron and steel are in general prepared by heating the metal in a suitable atmosphere or by oxidizing in the presence of certain aqueous or fused chemical reagents. Repeated alternate heatings in oxidizing and reducing gases give a comparatively heavy coating of black iron oxide, considered to be Fe_3O_4 . The etching and "coloring" processes (55) give thinner coatings, usually of a lower order of resistance to corrosion. The oxide coatings are always oiled, and undoubtedly owe some of their rust-resistance to this fact (56).

(1) *Bower-Barff Type.* The original Bower-Barff method consisted in heating the steel at 350 deg. C. and above, in air or sometimes in the presence of superheated steam; when a coating of ferric oxide had been formed, hydrocarbons were introduced which

served to reduce the ferric oxide, Fe_2O_3 , to ferrous-ferric oxide, Fe_3O_4 . This process and the variations of it give a coating which offers a very fair degree of resistance to corrosion. One modern variation which is used extensively consists in heating at a low red heat in a mixture of steam and benzene. The modifications of the Bower-Barff process are known under quite a number of names, e.g., the Swann, the Bontempi (58), the Gesner, the Weigelin, etc.

(2) *Heating With Oil, etc.* In this type of process, the steel is heated in volatilized oil or in a thick, smoky atmosphere, whereby a deep black oxide coating is produced. The Carbonia process is typical, in which the steel is heated at about 220 deg. C. in a mixture of burnt bone and oil. In other processes the steel is heated in burnt bone and charcoal, or in oil and sawdust. The steel may also be oiled first and then heated to a temperature ranging from 300 to 550 deg. C. The process of "blacking" in a forge is similar: the steel is cleaned of loosely adherent scale and then held while quite hot in the thick smoky flame from the forge.

(3) *Etching ("Browning," "Bluing," etc.).* Solutions of chemical reagents are applied to the steel with a cloth or sponge, the steel is allowed to oxidize for some hours while drying; the rust is then scraped off, leaving a thin adherent coat of oxide. The process is repeated a number of times, depending on the depth of color desired. The surface is then oiled. The following is a representative list of combinations of reagents that have been used for producing the respective colors:

BLACK	
	(Parts by Wt.)
Bismuth chloride.....	20
Mercuric chloride.....	40
Copper chloride.....	20
Hydrochloric acid.....	120
Alcohol.....	100
Water.....	1,000
Copper nitrate solution (10 per cent).....	700
Alcohol.....	300
Mercuric chloride.....	50
Ammonium chloride.....	50
Water.....	1,000
BROWN	
Alcohol.....	45
Iron chloride solution.....	45
Mercuric chloride.....	45
Sweet spirits of niter (ethyl nitrate + alcohol).....	45
Copper sulphate.....	30
Nitric acid.....	22
Water.....	1,000
Nitric acid.....	70
Alcohol.....	140
Copper sulphate.....	280
Iron filings.....	10
Water.....	1,000
BLUE	
Iron chloride.....	400
Antimony chloride.....	400
Gallie acid.....	200
Water.....	1,000
BRONZE	
Manganese nitrate solution (10 per cent).....	700
Alcohol.....	300

(4) *Niter Bath.* The cleaned steel is heated in fused sodium nitrate or potassium nitrate, or a mixture of the two, often with the addition of manganese dioxide. The color acquired by the steel depends on the temperature of the bath as well as its composition. Other fused oxidizing baths can probably be used also.

(5) *Temper Colors.* The "temper colors" seen on steel when it is tempered between 220 and 320 deg. C. are due to a thin layer of oxide. Such a layer of oxide is often applied as a protecting layer, the blue color being the one usually used. The steel is heated in free

air, and the various colors will be produced at the following temperatures:

	Deg. C.	Deg. F.
Pale yellow.....	220	418
Straw.....	230	446
Brown.....	255	491
Purple.....	280	536
Pale blue.....	300	572
Dark blue.....	315	599

The color depends somewhat on the duration of the heating and to a lesser extent on the nature of the steel.

(6) *Hot Oxidizing Solutions.* Boiling alkaline oxidizing solutions have been used, such as boiling sodium hydroxide solution, containing sodium picrate (Guerini process), sodium nitrate, sodium peroxide, etc. It seems probable that many oxidizing solutions would be found suitable. The nature of the steel affects the structure of the coating produced.

(7) *Miscellaneous.* Other processes for producing black coatings include the following: Immersion in boiling solution of lead acetate and sodium hyposulphite; making the iron the anode in an electrolytic cell, the oxygen from the decomposition of the water giving a coating of oxide; dipping in 10 per cent potassium bichromate solution, followed by heating in a smoky flame; copper plating by dipping in copper sulphate solution, followed by immersion in a solution of sodium hyposulphite and hydrochloric acid. A brown color may be produced by heating in steam with acid vapor for a few hours. A type of coating termed "black nickel" is used rather extensively. This is electrolytically deposited, but the commercial practice varies widely as to the composition of the bath used and hence also the coating. The deposit made from the sulpho-cyanate bath is most uniform in its composition and properties and is to be preferred, particularly if the article has received a preliminary coating of zinc.

b. Salts. In a coating of this type of rather wide commercial application, the iron at the surface is converted into a salt by immersing the steel in hot dilute phosphoric acid, sometimes containing manganese dioxide, soluble chromates, or other metallic salts. After the proper length of immersion, the steel is withdrawn and dried. The color is then grayish-white, but becomes black when oiled. This is called the Parker (57) or the Coslett process (59). Its resistance to corrosion is of the order of the light oxide coatings.

III. METHODS OF TESTING COATINGS

1. DESCRIPTION OF METHODS

Considerable difference of opinion has been expressed concerning the relative merits of the different types of the protective coatings, and various tests have been suggested to show the virtues of a particular coating. The basis on which some comparative tests are made is incorrect; for instance, the comparative values of lead, tin, orterne plate and zinc cannot be determined by treatment with sulphuric acid or ammonium chloride solutions, as is sometimes suggested; the Preece test should not be applied to sherardized coatings, and results obtained by this test on hot-dipped or plated coatings are not comparable. If the Preece test is made on the same type of material, by the same operator, under exactly the same conditions of time, temperature, concentration of solution, etc., comparable results may be obtained. There is no universal test that can be applied to the different kinds of protective coatings; each type must be considered alone and the limitations of each must be taken into account.

The usual methods for testing zinc coatings are the Preece test (24), the hydrochloric acid-antimony

chloride method (68), the basic lead acetate method (71), and the salt spray test (69), which recently has been receiving considerable attention. In addition to these purely chemical methods, metallographic measurements are also made of cross-sections of the coating of the material under consideration.

a. Stripping Tests. The Preece test is made by dipping, for a period of one minute each, the carefully cleaned sample in a solution of copper sulphate. The sample is washed in running water and lightly rubbed with clean waste between dips, and the appearance of bright adherent copper indicates the end of the test. The solution is prepared by dissolving 36 parts of commercial copper sulphate crystals in 100 parts of water and then adding some cupric oxide to neutralize any free acid. This solution is diluted with water until its specific gravity is 1.186 at 18 deg. C., and it should be used at approximately the same temperature.

HYDROCHLORIC ACID-ANTIMONY CHLORIDE METHOD

The hydrochloric acid-antimony chloride method for determining amount of coating on galvanized metal is as follows:

A sufficient number of specimens should be used in each test to have an area of not less than 25 sq.cm. (4 sq.in.). They are weighed (to the nearest milligram) and then dipped in 100 cc. (or more if necessary to cover the specimens) of concentrated hydrochloric acid (specific gravity 1.20), to each 100 cc. of which has been added 5 cc. of a solution made by dissolving 20 g. of antimony trioxide in 1000 cc. of concentrated hydrochloric acid. The same portion of hydrochloric acid may be used repeatedly up to five times, by adding before each immersion an additional 5 cc. of the antimony chloride solution. The samples are immersed in the solution for one minute. They are then washed and scrubbed in running water to remove the deposited antimony, and are dried and reweighed. The loss in weight represents the weight of the zinc coating, which is calculated directly to grams per dm.²; or to ounces per sq.ft. by multiplying the g/dm.² by 0.328 (or for practical purposes, by dividing by 3). Often it may be most convenient, on irregular shaped parts, to express the weight in grams (or milligrams) per piece, thereby avoiding uncertainty due to the area of a sample.

BASIC LEAD ACETATE METHOD

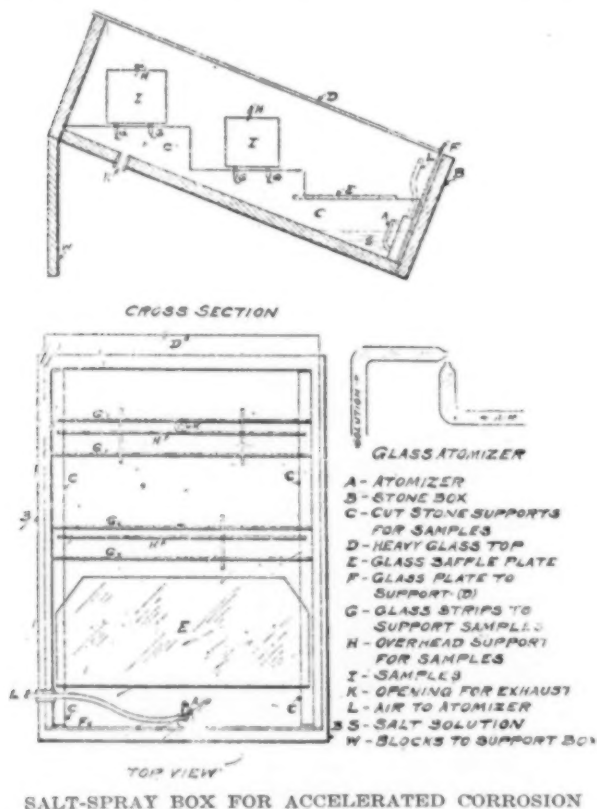
The basic lead acetate method is carried out essentially as follows:

The solution is prepared by dissolving 400 g. of crystallized lead acetate in 1 liter of water, to which is then added 4 g. of powdered litharge. After shaking, the solution is decanted or filtered and is diluted until the specific gravity is 1.275 at 15.5 deg. C. The weighed test specimens are immersed in a sufficient amount of this solution to cover them, and at the end of three minutes are removed and freed from adhering lead by rubbing or brushing lightly. They are again immersed for successive three-minute periods (usually four periods are sufficient) until a bright iron surface is exposed. The specimens are then cleaned, dried and reweighed, the loss in weight representing the weight of the zinc coating.

b. Salt Spray. The operation of the salt spray test has received considerable attention at the Bureau of Standards during the last two years, and although all types of protective coating have been tested, special attention was given to zinc coatings.

The test as conducted at the Bureau of Standards is made in an Alberene stone box, with a glass cover and glass supports for the samples. The construction is indicated in the accompanying diagram. The stone box will run down to the edge instead of dripping on the samples.

A 20 per cent solution (by weight) of commercial sodium chloride (20 g. salt and 80 cc. water, or 2 lb. salt and 1 gal. water), filtered if necessary, is used, and



with an air pressure of about 6 or 7 lb. per sq.in. a very fine mist is produced.

The compressed air is passed through a glass-wool or cotton plug and then through water to remove oil and dust, and to saturate the air with water vapor, which prevents concentration of the salt solution and crystallization of the salt on the tips of the atomizer. The baffle plate prevents the salt spray from blowing directly against the test pieces.

The samples, after washing with gasoline and ether to remove all grease, are placed in the spray box in a vertical position on the glass rods or strips. They are removed from the bath every twenty-four hours, washed with water, using a moderately stiff bristle brush, and after drying are carefully examined for the presence of red or yellow iron rust. The first appearance of rust indicates the conclusion of the test, but valuable information may be obtained by continuing the test and observing the extent of the corrosion produced by longer exposure.

If Alberene stone is not available, the box may be made of glass, stoneware, porcelain, waterproofed wood or any other insoluble and non-corrosive material, and all connections should be of glass or rubber.

2. COMPARATIVE VALUES OF DIFFERENT METHODS

The hydrochloric acid-antimony chloride and basic lead acetate methods are "stripping tests" and give the

total amount of coating on a surface; the Preece test has been used to show thin spots and also to show, in a general way, the thickness of the coating. The lead acetate method may also be used to show thin spots, but used in this way is liable to show the same irregularities that led committee A-5 of the A. S. T. M. to condemn the Preece test (75).

The comparative value of the hydrochloric acid-antimony chloride and the basic lead acetate methods for stripping are discussed in the report of committee A-5 for 1917 (75), and either is considered satisfactory for sheet metal and wire, which were the materials tested.

The hydrochloric acid-antimony chloride method has been used at the Bureau of Standards almost entirely for stripping because it removes the coating more quickly and can be applied to material of any shape and to all types of zinc coatings. The basic lead acetate method does not lend itself to irregular pieces such as bolts, nuts, screws, etc., or parts with holes in them, on account of the difficulty of removing the precipitated lead from the small depressions or holes and on account of the possible failure to react with sherardized coatings, which is also characteristic of the Preece test.

The hydrochloric acid-antimony chloride solution usually removes plated zinc completely in from five to fifteen seconds and hot-dipped zinc in less than thirty seconds, but it has often been found that sherardized zinc is not completely removed during a one-minute immersion, four immersions sometimes being required to remove all the coating.

PROGRESSIVE LOSS OF COATING

The following results illustrate the progressive loss of coating when four pieces of sherardized sheet metal, 1 in. square, were dipped in the hydrochloric acid-antimony chloride solution for periods of one minute each.

LOSS OF WEIGHT IN GRAMS

	A	B	C	D
First dip	0.3371	0.4102	0.3966	0.8380
Second dip	0.0490	0.0158	0.0171	0.0477
Third dip	0.0017	0.0017	0.0017	0.0040
Fourth dip	0.0010	0.0008	0.0010	0.0007

The fourth value may be attributed to iron, as these figures are of the general magnitude of those obtained when bare iron is treated with the acid mixture used in stripping.

The following figures indicate that the acid method of stripping may be more accurate for electrolytic zinc than the basic lead acetate method which was shown by accurately weighing the amount of zinc deposited on some iron sheets and then stripping them:

Method of Stripping	Weight of Coating in Grams		Per Cent Coating Found
	Deposited	Stripped	
Lead acetate	0.2888 0.1694	0.2537 0.1572	88.0 93.0
Hydrochloric acid-antimony chloride	0.2141 0.1965	0.2157 0.1992	100.7 101.4

The salt spray test has been applied to a large number of samples, some of which were taken from stock at various plants, while other samples were prepared especially for this purpose. These tests were made in conjunction with stripping tests and metallographic examination. A study of the results obtained indicates that there is no close agreement between the life of a coating determined by the salt spray test, the amount of zinc determined by stripping and the thickness of the coating measured metallographically. The following

examples taken from the large number tested illustrate the differences between amount of coating determined by the two methods and the variation shown by the salt spray test.

Sample	Thickness of Coating (Inches)— Microscopic Examination of Cross Sections		
	Stripping	Average	Average Minimum
A (hot dipped).....	{ 0.00276 0.00307	0.00303 0.00646	0.00173 0.00339
B (hot dipped).....	{ 0.00191 0.00185	0.0028 0.0046	0.00233 0.00268
C (hot dipped).....	{ 0.00181 0.00172	0.0039 0.0029	0.00260 0.00189

Salt Spray Test		
Type of Coating	Thickness of Coating (by Stripping)	No. of 24-Hr. Days Required for First Appearance of Rust
Electroplated.....	0.00040 inch	3
Electroplated.....	0.00077	15
Electroplated.....	0.00073	9
Hot dipped.....	0.00109	5
Hot dipped.....	0.00133	6

The tests from which the above conclusions were drawn were repeated to see if more consistent results could be obtained, but no better agreement was found. It was thought these differences might be due either to the manipulation of the salt spray test, to the very irregular shapes of the test pieces, or a lack of uniformity in different samples of the same kind from the same lot. It was found on investigation that samples of plated and hot-dipped sheets and chilled-cast zinc placed in the salt spray tank in a vertical position corroded more rapidly than those in a horizontal or an inclined position. It was also found that zinc is not removed by immersion in a solution of salt nearly as rapidly as it is by a spray of the same solution, and consequently zinc in the holes or depressions in the surface of a specimen where the salt solution may collect will not be removed as rapidly as at other places. It becomes evident that although the thickness of plated zinc on recessed parts is less than on outer surfaces they may not show failure as rapidly as the outer surfaces. It was also found that the amount and distribution of zinc on different samples of sheet metal, prepared at the same time and presumably under similar conditions, varied so much that the results obtained on one of several samples could not be taken as characteristic of the set.

TO REMOVE BASIC ZINC CARBONATE COAT

A hard and adherent coat of basic zinc carbonate nearly always forms on the surface of the test piece when exposed to the action of the salt spray, and efforts to remove this completely without affecting the metallic zinc have not been successful. Treatment with acids undoubtedly removes zinc, although Tambou (74) recommends a mixture of ammonium carbonate, ammonium chloride and ammonia for differentiating between zinc oxide and metallic zinc. This solution was not found satisfactory, as it attacks metallic zinc somewhat readily. A zinc plated sheet (51.7 sq.cm.) immersed for periods of 15 minutes each in a solution lost weight as follows:

First dip.....	6.4 mg.
Second dip.....	3.6 mg.
Third dip.....	4.1 mg.
Fourth dip.....	4.2 mg.

After trials of various methods to remove the basic zinc carbonate, the one finally adopted is to brush the sample daily in running water with a moderately stiff bristle brush. This was found to have practically no effect on metallic zinc, but it did not remove all the

zinc salts. This layer must have some protective action, and as it is not uniformly distributed, zinc will be removed more rapidly at some places than others, producing erratic results.

The salt spray test as a measure of the relative value of zinc coating depends on the time required for the complete removal of the zinc at the thinnest point, which is usually indicated by the appearance of iron rust. It was thought that iron exposed to the action of the salt fog would show rust almost at once, but this is not always true. Numerous cases have been observed, however, in which areas of iron as large as 1 sq.cm. have been completely freed from zinc, as shown metallographically, yet no rust appeared. This is probably due somewhat to the type of iron exposed and also to the protective action of the adjacent zinc through the strong salt solution as electrolyte, for it can readily be shown that certain steels corrode more readily than others and that the "zone of protection" exerted by zinc on iron increases readily with the concentration of the salt solution. It is difficult to explain the quick appearance of iron rust on zinc-coated material in the salt spray test unless it is assumed that there is an insufficient layer of salt solution between the zinc and exposed iron to allow the zinc to exert its electro-positive nature or that the basic zinc carbonate which is formed collects in such a way that it insulates the zinc from the iron and destroys its protective effect.

SALT SPRAY TEST REGARDED AS BEST

Although the salt spray test is subject to many objections, it may be regarded as the best test for zinc coatings that has yet been developed. It is especially useful in determining the relative value of zinc coatings for marine exposure. No definite statement can be made about the life of zinc coating in this test, but in a general way, a sample showing rust spots in less than 1 day (24 hours) should be regarded as unsatisfactory, while a life of two or three days would indicate a coating that could safely be used under moderate conditions of exposure, and a life of at least 4 to 6 days should be required for severe conditions of exposure.

Since electro-negative coatings accelerate the corrosion of iron at exposed points, continuity of coating is of more importance than the thickness of the protecting layer. Any test which will effectively show the presence, number and approximate size of breaks or pin-holes may be used to indicate in a general way the quality of the coat as applied. The salt spray test will detect "pin-holes" in a comparatively short time (usually from 3 to 10 hours) and on longer exposure give some indication of the probable life of the protective coating. But the comparative value of the various metals cannot be determined by this method alone; purpose and service conditions also must be taken into consideration.

OTHER TESTS

Other tests which detect lack of continuity in metal coats have the advantage of speed, while their application does not spoil the part tested for subsequent use. Such tests are based upon color reactions which take place between the solution and exposed (uncoated) iron. Pin-holes in most electro-negative coatings can be detected readily by immersing the sample in a 1 per cent solution of sodium ferricyanide in 2 per cent sulphuric acid. The appearance of a blue precipitate at any point indicates a hole in the coating, or exposed

iron. This test is readily applied to the electro-negative coatings such as lead, copper, lead-tin, or lead-antimony alloys. Acetic acid may be substituted for sulphuric acid, but the action will be slower. Similar results may be obtained by exposing to the air a specimen which has been dipped first in dilute acetic acid and then in a warm solution containing 5 per cent hydrogen peroxide. Breaks in the coating are indicated by a blue precipitate.

The oxide coatings cannot be tested by any method so far developed because the iron in the coating gives the same results as the base metal itself, and their protective value depends often on the amount of oil in the coating.

The phosphate coatings are more readily tested, but in this case, too, the iron in the coating makes it difficult to draw definite conclusions. A great many tests have been made at this Bureau on samples prepared by treatment with the various phosphoric acid solutions, and it can be definitely stated that this treatment does not give satisfactory protection for steel parts that are exposed to water, salt air, moist atmosphere, or considerable friction, but it has some merit if conditions of exposure and handling are very moderate. The value of this treatment is increased if the treated surfaces can be frequently oiled, but this will not materially increase its resistance to mechanical action. The experience of this Bureau indicates that this treatment has not been successfully applied to case-hardened products without removing most, if not all, the hardened surface by sand blasting or pickling.

IV. RECOMMENDATIONS CONCERNING COATINGS

1. Zinc coatings should be given preference over all others when the object of the coating is protection against corrosion only.

2. For general use on large smooth surfaces, sheets, rods, wires, pipes, etc., the hot-dipped zinc coatings are entirely satisfactory, though some of the other processes are more economical in the amount of zinc used. On articles which must be sharply bent or otherwise shaped, too heavy coatings of this hot-dipped type should not be used on account of the tendency of the coating to flake off at such points.

3. One oz. of zinc per sq.ft. of surface exposed (0.0017 in. thickness) may be considered as satisfactory for most purposes, but less may be sufficient if evenly distributed.

4. Of the different types of zinc coatings the "hot-dipped" and sherardized are not to be recommended for hardened and tempered steels (springs, etc.); the plated zinc and the sherardized coatings are both recommended for accurately machined parts; threaded portions, however, are best coated by sherardizing; the "spray" coatings are valuable for large or complex parts which must be coated *in situ* or after assembling.

5. For indoor use and to a limited extent outdoors, for parts which are so placed as to be easily inspected and which are kept well oiled, other coatings than zinc, e.g., the oxide and other black finishes, may be used. For severe service, zinc only should be depended upon.

6. In general, nothing is gained, from the standpoint of resistance to corrosion, by first coating an article with copper, or a similar metal, and then finishing with zinc. If a zinc coating is to have a black finish, "black nickel" may be used as a finish.

7. The use of oil and like substances on any type of coating is to be strongly recommended. The life of

zinc coatings, particularly those of a porous character, may be prolonged almost indefinitely by periodically oiling them.

8. The time required for the appearance of rust on zinc coated articles when exposed to salt spray may in a general way be taken as an indication of whether the coating is satisfactory for outdoor exposure, e.g.:

24 hours	unsatisfactory
48 to 72 hours.....	for mild exposure
96 to 144 hours.....	for severe exposure

Potash From Wood Ashes

An investigation concerning the production of potash from wood ashes, conducted by the U. S. Forest Products Laboratory at Madison, Wis., disclosed the following facts:

The ash content of hardwoods ranges from 0.5 per cent to 3.02 per cent, with an average of 0.61 per cent. The ash content of the coniferæ seems to vary from 0.02 to 0.82 per cent, with an average of 0.30 per cent. There may, however, be very wide variations in the ash content of the same species, as is instanced by black walnut with a minimum ash content of 0.21 per cent, a maximum of 1.96 per cent, and an average of 0.79 per cent; or chestnut oak, whose minimum, maximum and average ash contents are respectively 0.33 per cent, 1.96 per cent and 0.77 per cent.

The potash content of pure, well-burnt ashes may be very high, ranging from 10 per cent up to 35 per cent. These figures are, however, of but little commercial value, since all commercial ashes contain impurities, such as sand, sawdust or charcoal, and these impurities may make up a very large per cent of the total ash. The potash content of commercial wood ashes may vary over a comparatively wide range, depending somewhat on the wood and the kind of furnace or stove used. The average of 111 analyses made in Connecticut from 1906 to 1915 was 3.6 per cent K₂O.

The initial cost of a potash plant of 24 leachers, including building, is between \$3000 and \$4000. The cost of manufacture of potash, not including the cost of the wood ashes, will vary from about 7 to 17c. a lb., depending upon the kind of ashes obtained and whether or not the plant is running at full capacity.

It is evident, therefore, that the manufacture of potash from wood ashes will not be a paying proposition when normal prices are resumed, except in those cases where the plant has already been paid for and is owned by the potash maker who makes no charge for his own labor but accepts his profit as compensation for his work. Under these conditions the cost of manufacture of potash, exclusive of the cost of ashes, may be reduced to about 5c. a pound.

War Department Disposes of Lead

Disposition of the surplus stocks of lead owned by the War Department is being made at current local market prices in the community in which the surplus is held. This surplus is scattered throughout the country, and in no one place is there a large quantity. Reports from the various bureaus show a total amount of 7000 tons of lead to be in possession of the War Department. This surplus of 7000 tons represents but a small percentage of the year's production of lead and is not sufficient in quantity to affect the market in any way. This lead is not sold in quantity at one time but in small quantities in various places.

Treatment of Cuprodescloizite for Extraction and Recovery of Vanadium, Lead and Copper

Preliminary Experiments to Determine Best Method of Preparation and Extraction of Vanadium From the Ore—Niter Cake-Sulphuric Acid Extraction Most Economical—Leaching Tables—Copper and Lead Recovered Sufficient to Pay Costs

By J. E. CONLEY*

OWING to the strong competition of the Peruvian patronite as a source of vanadium, the production of this metal from ores found in the United States has in a measure been neglected. The rumored decrease in the available supply from Peru, and the continued demand for vanadium in the steel industry, are sufficient grounds to encourage and stimulate the production of this important metal in this country.

Some vanadium is being obtained by the treatment of roscoelite and also as a by-product in the treatment of carnotite ores for radium. The treatment of ores for vanadium alone has not been extensively done and certainly warrants the attention of companies and individuals owning vanadium properties, as well as of the consumers themselves.

A lead-copper-vanadium mineral, evidently cuprodescloizite, has presented itself as a possible source of vanadium worthy of consideration. For this reason, an investigation into the metallurgy of the vanadium especially applied to this mineral was deemed justifiable.

A sample of this cuprodescloizite was obtained by the Bureau of Mines through the courtesy of Mr. L. C. Shattuck and Mr. Houle of the Shattuck-Arizona Copper Co. of Bisbee, Ariz., and to whom we are indebted for their kindness.

DIFFICULT TO MINE

It is claimed by those who have examined the mine that a considerable amount of this mineral is available but likely to present some difficulty in mining, owing to the nature of the deposit. The mineral is found in a large vug, or cavity, as a deposit on a brecciated quartz.

The quantity of ore in this deposit, although not available at present owing to the caved-in condition of the mine, is best indicated by an extract from a letter recently received from the Shattuck-Arizona Copper Co. and is as follows: "At one time in 1915, the vanadium-bearing ore was exposed on the 600 level for a length of 200 feet, average width 3 feet and total height 600 feet. In this block was estimated a tonnage approximately 3000 tons of ore averaging 10 per cent V_2O_5 (vanadium pentoxide)"; and "In addition to the so-called high-grade ores a large tonnage of ore assaying from 1 to $1\frac{1}{2}$ per cent V_2O_5 is exposed."

THE MINERAL DESCRIBED

The sample submitted to the Bureau of Mines consisted of a large sample weighing nearly 40 lb., and composed largely of the mineral deposited on hard quartzite fragments so as to form a cementing ma-

terial. The mineral itself is admirably described by Mr. R. C. Wells¹, who examined a specimen several years ago and describes it as follows:

"The mineral occurs in the form of stalactites. The smaller aggregates radiate from a narrow base and end in round clusters $\frac{1}{2}$ mm. in diameter. The larger growths occur in reniform masses several centimeters in diameter. The latter are coated with a red powder, but the smaller aggregates have an olive hue. The fractured surface of all varieties possesses a dark-brown luster and shows a radiating structure. The streak is a dark olive buff."

There is this difference, however, that the red powder, evidently vanadium pentoxide, occurs as a thin layer between the quartzite and the deposit of mineral itself, rather than being found as a coating on the mineral. The fractured surface also has more of a bluish-gray metallic luster than a dark-brown color.

PREPARATION OF THE SAMPLE

The sample described was taken and ground to 20 mesh, and gave on analysis the following:

Insc.	52.50 per cent
V_2O_5	8.06 per cent
CuO	7.31 per cent
PbO	23.02 per cent
Fe	2.36 per cent

From the above analysis it is seen that the ore would also be valuable as a lead and copper ore if found in any quantity. The iron was evidently introduced by the grinding, since scarcely more than a trace is present in the original sample. This was to be expected, owing to the extreme hardness of the quartzite and to the difficulty encountered in grinding it. The phosphorus and arsenic in the sample were not determined, but were shown to be present by qualitative tests. A screen test made on the sample gave the following figures:

Mesh	Per Cent
Through 20 on 40	17.38
Through 40 on 60	19.13
Through 60 on 80	8.48
Through 80 on 100	8.86
Through 100 on 120	3.53
Through 120 on 150	1.63
Through 150 on 200	6.23
Through 200	34.76
Total	100.00

Very little attempt was made to improve the grade of the ore by concentrating. Some attention, however, was given to the possibility of affecting some concentration by careful screening. From the nature of the ore it was thought that this scheme might possibly be applied.

The mineral is softer than the quartz and would consequently be expected to grind more readily and,

*Published by permission of the Director of the U. S. Bureau of Mines.

¹Amer. Jour. of Science, 4, 36. 636-638, 1913.

therefore, could be separated from the quartz by proper screening. A test was made on a ground sample to determine the possibilities of this procedure. The results obtained are given below:

Mesh of Product	V ₂ O ₅ Per Cent	Copper, Per Cent	Lead, Per Cent
Retained on 20.....	7.48	5.05	18.17
Passed through 20.....	8.06	5.95	21.37
Passed through 150.....	8.58	.....	.....

It is seen that the fine product passing the 150-mesh sieve is only of a slightly better grade than that of the material retained on the 20-mesh. From these results it would seem that the slight improvement in the grade of the ore is scarcely sufficient to justify the treatment.

As confirmatory of the above results, it was noticed that in preparing a sample of the 20-mesh material for analysis by grinding in an agate mortar and frequently screening off the fine ore a considerable portion of the mineral persisted with the quartz until practically all of the sample had been ground. From these facts it seems that concentration by screening could not be recommended.

Other methods of concentration were not tried for several reasons. First, the ore, since it contained 8 per cent of vanadium pentoxide, was already fairly high; and, second, since the gangue is a hard quartz, the grinding costs would be necessarily high, and therefore to be avoided. The coarse material would also facilitate filtering and be desirable to the final recovery of the lead in the subsequent sliming process. Some difficulty would also be encountered in slime losses, since the red powder of V₂O₅ would tend to be carried off as slime and would necessitate special treatment.

The mineral itself, neglecting the powder, could be easily concentrated as would no doubt be necessary on the low-grade material. The cuprodesclozite is fairly heavy, while the quartz is a light mineral. A rough test made by passing a small quantity of the ground sample over the Wilfley table confirmed the above assumptions and gave excellent promise of a good concentration and clean separation.

METHODS TRIED FOR EXTRACTION OF VANADIUM

The object of experiments on this ore was to determine the best procedure for extraction of the vanadium and then to work out a method for recovery of the lead and copper if possible. Methods that were found ill-suited for a good extraction of the vanadium were given but little consideration. The schemes tried, with a brief statement of the results obtained by each, are given as follows:

1. *Leaching With Hydrochloric Acid:* Experiments were made with hot and cold dilute and concentrated hydrochloric acid. It was found that if used in large excess this acid decomposed the ore fairly well, but the vanadium was deposited on the insoluble residue as the oxide before the solution could be filtered. An extraction of about 70 per cent was obtained with the amount of acid commercially feasible.

2. *Leaching With Sulphuric Acid:* Experiments were made with dilute and concentrated sulphuric acid in the hot and the cold. The results finally obtained were found to be quite satisfactory, and are given later in this report.

3. *Treatment With Concentrated Sulphuric Acid Under Pressure:* These tests were made by mixing the ore with sufficient acid to make a thick paste and

then heating in a capped iron tube for from 2 to 3 hours at 400 deg. C. Some of the experiments showed only a 15 per cent extraction, the best obtained being around 70 per cent. In one or two of the earlier tests which were made in a thick-walled hard glass tube, which burst before reaching 400 deg. C., an extraction as high as 85 per cent was obtained, a fact which proves that the high temperature and pressure are undesirable.

4. *Fusion With Niter Cake:* The preliminary tests were made with c.p. sodium bisulphate, which was later replaced by the commercial salt commonly known as niter cake. As a whole, the fusions with niter cake alone were found unsatisfactory, in that even by using as much as three and four times as much cake as ore, the extractions could not be raised above 85 per cent. It was found, however, since approximately two-thirds of the ore could be decomposed by heating it with an equal weight of the niter cake, that this fusion could be satisfactorily used as a preliminary treatment, followed by a sulphuric acid leach.

5. *Fusions With Soda Ash, Soda Ash and Caustic Soda, and With Soda Ash and Salt:* Fusions were made with the above mentioned fluxes to obtain a vanadium soluble slag. Carbon was added as a reducing agent to obtain the lead as a button. It was found that the amount of fluxes required to obtain a sufficiently fluid slag was very large, and the amount of vanadium extracted by leaching the slag with water was only from 65 to 70 per cent.

A straight alkaline leach was not tried on the ore, since the slag obtained in the above fusions after being pulverized and heated for some time gave practically the same conditions.

6. *Volatilization of the Vanadium as the Oxytrichloride With Chlorine and as the Tetrachloride With Hydrochloric Acid Gas:* From the theoretical standpoint, this method is the most ideal of all the methods tried. The vanadium would be recovered as a high-grade oxide, and the lead and copper in the tails rendered soluble in hot water. The treatment requiring chlorine would eliminate the arsenic, since the ore would have to be reduced with either carbon or hydrogen at a red heat, which would, no doubt, volatilize the arsenic. The hydrochloric acid gas treatment was found applicable on the original ore, but the arsenic was carried over with the tetrachloride. Both of these methods gave promising results on small samples of one to two grams, but when tried on larger samples gave very poor recoveries.

7. *Chloridizing Roasts With NaCl and With NaCl and Sulphur:* A few chloridizing roasts were made in an attempt to render the vanadium soluble. The amount of vanadium rendered soluble by this treatment was only a small percentage of the total. The preliminary tests gave such poor promise of success that this method of attack was given but slight consideration.

8. *Combination of Niter Cake-Sulphuric Acid Treatment:* This treatment is the one that was finally considered to be the most economical and, in general, the most satisfactory. Details and results are given more fully in other parts of this report.

Since the niter-cake fusion is given as a preliminary treatment of the ore, it was thought advisable to give a few of the results obtained in the tests. A considerable number of experiments were made to fix the conditions best suited for a maximum vanadium

extraction. The preliminary fusions were made with the fused c.p. bisulphate which was later replaced by niter cake. The results obtained are given in Table I.

TABLE I.

No. of Test	Weight of Ore	Weight of $\text{Na}_2\text{S}_2\text{O}_8$	Ratio Ore to Flux	Extraction V_2O_5 Per Cent	Remarks
1	10 g.	5 g.	2:1	11.3	Practically all of SO_2 driven off by blast.
2	10 g.	5 g.	2:1	38.0	Part of SO_2 driven off.
3	10 g.	5 g.	2:1	44.4	Heated only to fusion.
4	10 g.	8 g.	10:8	65.7	Heated only to fusion.
5	10 g.	10 g.	1:1	85.7	Heated only to fusion.
6	10 g.	12 g.	5:6	83.5	Heated only to fusion.
7	5 g.	7.5 g.	2:3	85.7	Heated only to fusion.
8	5 g.	10 g.	1:2	87.2	Heated only to fusion.

Another series of tests very similar to those given in Table I were made with niter cake, and the results obtained are given in Table II.

TABLE II.

No. of Test	Weight of Ore	Weight of Flux	Ratio Ore to Flux	Extraction V_2O_5 Per Cent	Remarks
1	5 g.	5 g.	1:1	44.1	Scarcely all of niter cake fused.
2	5 g.	5 g.	1:1	66.2	Heated only to fusion.
3	5 g.	5 g.	1:1	48.4	A little SO_2 driven off.
4	5 g.	5 g.	1:1	29.1	SO_2 driven off by blast.
5	5 g.	6 g.	5:6	70.6	Barely fused.
6	5 g.	7 g.	5:8	80.3	Barely fused.
7	5 g.	10 g.	1:2	85.1	Barely fused.

The results, in general, show that the extractions are a little lower in the niter-cake fusion than in the bisulphate fusion, a fact which is no doubt explained by the presence of free nitric acid in the niter cake. This effect could in a measure be offset by adding a small quantity of a suitable reducing agent.

From these results, it is seen that the best extraction is obtained when the mixture is heated only sufficiently long to melt all of the niter cake. On larger samples in which the heat is applied more slowly the fusion becomes almost a sulphatizing roast, since very little fusion takes place. On the small samples a distinct fusion is obtained when the heat is applied more rapidly. In general, the extraction is a little better on small samples than on the larger, but as is shown in Table V about two-thirds of the vanadium is consistently extracted with a ratio of 1:1. The extraction is poor if the heating is prolonged, even if the amount of flux is increased, as is shown in Table III.

TABLE III.

No. of Test	Weight of Ore	Weight of Niter Cake	Extraction V_2O_5 Per Cent	Remarks
1	25.0 g.	25.0 g.	56.0	Samples heated longer than advisable.
2	25.0 g.	30.0 g.	61.1	Samples heated longer than advisable.
3	25.0 g.	35.0 g.	62.1	Samples heated longer than advisable.
4	25.0 g.	40.0 g.	54.3	Samples heated longer than advisable.
5	25.0 g.	45.0 g.	50.8	Samples heated longer than advisable.
6	25.0 g.	50.0 g.	54.3	Samples heated longer than advisable.

In order to determine the amount of acid that would be required to react with all of the bases, an analysis of the ore was made. The amount of acid thus required from a theoretical standpoint was calculated and found to be approximately equal to 30 per cent of the weight of the ore. Several series of tests were made using this amount of acid, which was gradually increased up to the amount necessary for a good extraction.

A considerable number of tests were made, varying the amount of acid and the time and temperature of heating. The results obtained are given in Table IV. As the quantity of acid used was insufficient to cover all of the sample, enough water was first added to moisten the ore. The acid was carefully added from a burette and the samples heated as indicated at a temperature of 175 to 180 deg. C.

TABLE IV.

No. of Test	Weight of Ore	Cc. Acid H_2SO_4	Weight of Acid	Per Cent Excess Over Theoretical	Time Heated, Minutes	Extraction, Per Cent
1	10 g.	1.6	2.94	None	15-15	57.2
2	10 g.	1.8	3.31	12.5	15-15	61.1
3	10 g.	2.0	3.68	25.0	15-15	69.0
4	25 g.	4.0	7.36	None	60-15	60.4
5	20 g.	4.8	8.83	50.0	90-15	77.7
6	25 g.	6.0	11.04	50.0	60-15	82.3
7	25 g.	8.0	14.72	100.0	15-15	85.1
8	25 g.	8.0	14.72	100.0	30-15	90.1
9	25 g.	8.0	14.72	100.0	45-15	95.7
10	25 g.	10.0	18.40	150.0	15-15	93.5
11	25 g.	10.0	18.40	150.0	30-15	95.9
12	50 g.	20.0	36.80	150.0	45-15	94.4

The table shows that a 95 per cent extraction can be obtained with an amount of acid equal to twice the theoretical quantity. This fact was confirmed by a number of other tests. The first figure under the heading "Time Heated" refers to the actual time the samples were heated with acid alone and the second figure indicates the time of heating after diluting with 60 to 75 cc. of water.

Some trouble was encountered in the earlier experiments owing to the tendency of the vanadium to separate from the solution before the filtering could be accomplished. An attempt was made to eliminate this trouble by passing a slow stream of sulphur dioxide through the solution during the treatment. This procedure was found to prevent the precipitation of the vanadium and to increase the extraction a small amount, but it was later found to be wholly unnecessary, in that the same object could be attained by adding only sufficient water to permit filtering and washing. From these results it would be possible to obtain an extraction of 95 per cent by using 1172 lb. of 66 deg. B. sulphuric acid per ton of ore.

TREATMENT BY COMBINATION OF NITER-CAKE FUSION AND SULPHURIC ACID LEACH

This treatment consists of subjecting the ore to a preliminary fusion with niter cake followed by a hot-water leach, then treating the residue with sulphuric acid. As previously stated, it was found that by heating the ore with an equal weight of niter cake approximately two-thirds of the ore could be decomposed and

TABLE V.

Niter-Cake Fusion Treatment								H ₂ SO ₄ Leach of First Residue							Results		
No. of Run	Weight of Ore, Grams	Weight of Niter Cake	Weight of Residue	Extraction			Residue, Per Cent Pb	Ce. Acid	Weight of Acid, Grams	Weight of First Residue	Extraction			Combined Extraction			
				Per Cent V ₂ O ₅	Per Cent Cu	Per Cent Pb					Per Cent V ₂ O ₅	Per Cent Cu	Per Cent Pb	Per Cent V ₂ O ₅	Per Cent Cu	Per Cent Pb	
1	48	48	42.5	70.20	74.50	58.3	24.49	6.8	12.62	41.5	22.60	24.40	25.5	92.80	98.9	83.8	
2	100	100	89.8	62.75	65.78	66.3	24.56	a. 3.70	6.82	20.0	34.40	33.15	.....	97.15	98.9	.....
								b. 3.08	5.66	20.0	28.60	28.50	.....	91.35	94.3	.....
								c. 2.47	4.55	20.0	28.12	26.70	.....	90.37	92.5	.....
								d. 1.85	3.42	20.0	19.36	23.41	.....	82.11	89.2	.....
3	100	100	89.7	59.70	63.1	59.9	23.40	a. 3.70	6.82	20.0	30.90	32.50	.....	90.60	95.60	89.0
								b. 3.08	5.66	20.0	27.15	30.20	.....	86.85	91.50	.....
								c. 2.47	4.55	20.0	26.70	23.85	.....	85.40	86.95	.....
								d. 1.85	3.42	20.0	25.20	22.70	.....	84.90	85.80	82.5

the corresponding values extracted. The remaining values are then extracted by leaching the residue with about one-half as much acid as is required in the straight acid treatment. This procedure substitutes an amount of niter cake worth about two-thirds the value of the acid that would be required. This method would entail a slightly increased cost for labor and equipment, but the utilization of the cheaper chemicals would no doubt still render the use permissible from the standpoint of economy.

EXPERIMENTS WITH NITER-CAKE TREATMENT

The initial treatment with niter cake should be made under conditions approximately the same as those found to be the most desirable under the experiments on that fusion. The ore should be mixed with the pulverized niter cake and heated barely to fusion. Sufficient water to break up the ore and to permit washing should be used; and boiling should not be continued any longer than necessary to accomplish this. In the experiments to determine the minimum amount of acid to treat the residue from the fusion, the residue was dried and divided into portions for the tests. In the working process the drying would be unnecessary, since the acid could be added directly to the moist residue. A fairly good idea of the results obtained by this method can be had by reference to Table V.

The percentage of the lead remaining in the residues as sulphate was not determined in all cases, owing to the difficulty of recovering the residues quantitatively. In practically all instances where analyses were made, more particularly on the smaller tests on which the residues could be better collected, the percentages of lead as sulphate ran a trifle lower than the vanadium extracted, so that a close approximation can be made in this manner. It was originally planned to allow the lead to remain in the residue, and to concentrate it by sliming, as is being successfully done with radium-barium sulphate in radium extraction, so that the lead would be obtained either as a high-grade lead residue or as a crude lead sulphate.

RESULT OF ACTUAL SLIMING TEST TO DETERMINE RECOVERY OF LEAD SULPHATE FROM RESIDUES

An actual sliming test was made to determine the possibilities of recovering the lead sulphate from the residues. A typical sample of the residue obtained by treating a quantity of the ore with concentrated sulphuric acid was placed in a large beaker and water added. The mixture was then violently stirred in order to put the lead sulphate in suspension and then decanted. This procedure was repeated several times and the

slimes allowed to settle and were recovered as concentrates. The test gave the following results:

	Grams
Weight of ore used.....	400.00
Weight of residue obtained.....	330.00
Weight used for sliming test.....	300.00
Weight recovered as slimes.....	165.00
Weight recovered as tails.....	132.00
Percentage lead in original ore.....	21.67
Percentage lead in residue.....	25.08
Equal to 28.89 per cent PbSO ₄	
Percentage lead in slimes.....	43.09
Equal to 49.76 per cent PbSO ₄	
Percentage lead in tails.....	3.52
Equal to 4.06 per cent PbSO ₄	
Percentage lead recovered.....	94.70

The test required considerable water to obtain a good recovery, but this would not be a serious objection commercially, since the same water could be used repeatedly. It would also be desirable in that it would remove the last traces of vanadium not previously washed out, which could be allowed to accumulate in solution until present in sufficient amount to recover.

The values given in Table V for lead extracted were determined by dissolving the lead from the residues with ammonium acetate, so that the figures really represent the lead present as the sulphate. It was assumed that the lead converted to the sulphate could be considered as extracted, since it would be subject to recovery in the subsequent sliming process.

RECOVERY OF THE VANADIUM FROM THE SOLUTIONS AS IRON VANADATE

The vanadium recovered by this treatment would be in the form of iron vanadate containing as a minimum about 35 per cent V₂O₅. In the experiments made, a product of variable V₂O₅ content was obtained according to the care used in neutralizing the acid solution and time of boiling. The iron necessary for the precipitation was introduced by adding scrap-iron, which simultaneously replaced the copper. The vanadium was then thrown out from the solution by carefully adding a strong solution of caustic soda until the solution gave but a very slight acid reaction, and then boiling for two to three hours. By this procedure some samples of iron vanadate containing as much as 50 per cent V₂O₅ were obtained with scarcely any of the vanadium passing through into the filtrate as indicated by qualitative tests with hydrogen peroxide.

The copper thrown out of solution by the iron was at first in the form of bright flakes which gradually darkened as the replacement continued. This copper when filtered off and dried was almost black, due no doubt to the impurities from the iron and arsenic from the ore. The cement copper on analysis gave a copper content of 92 per cent, which would easily be converted to the pure metal in the reverberatory furnace.

Some difficulty was encountered with the copper, which must be thoroughly removed from the solution to prevent its being carried down in the iron vanadate. It was found, however, that by permitting the scrap-iron to remain in the solution for a number of hours practically all of the copper could be thrown out of the solution and the iron vanadate then obtained would be nearly free from copper. This procedure allowed a considerable excess of the iron to go into the solution, a fact which did not materially affect the grade of the precipitate, and is objectionable only from a standpoint of economy of iron. As previously stated, the real important factor in controlling the grade of the iron vanadate is the care used in the neutralization with caustic soda.

The neutralization also consumed a considerable quantity of caustic soda, which would be expected, by the necessity of using so large an excess of acid to obtain a satisfactory extraction. This could in a measure be overcome by boiling off a portion of the free acid, and also suggests the possibility of recovering some of the acid.

As an example of the products obtained, by varying the amount of alkali used in the neutralization the following figures are given:

No. of Test	Alkali Added Cc.	Grade of Ppt. Obtained, Per Cent V_2O_5
1	24.99	50.52
2	30.30	48.55
3	32.90	30.37

(1 cc. alkali = 0.08644 grams NaOH)

In these tests three aliquots of 50 cc. each of a solution containing 0.0142 g. of V_2O_5 were taken. The procedure in these experiments was as follows: One-fourth, one-half and three-fourths respectively of the acidity of the solution was neutralized before adding the iron strips to replace the copper. After the copper was filtered off, the remainder of the alkali was added, and the solutions boiled for two and one-half hours. There is little difference between numbers 1 and 2, but evidently too much alkali was added to number 3.

TWO PROCESSES OF NEUTRALIZATION

Two procedures were tried in the neutralization: (1) To neutralize a portion of the free acid before adding the iron strips for the purpose of lowering the iron consumption, and (2) adding the iron directly to the acid solution and neutralizing after the removal of the copper. So far as affecting the grade and recovery of the vanadium, there is really very little preference, but (1) is probably more desirable for the saving in iron. A satisfactory iron vanadate is obtained by both methods.

ESTIMATE ON VALUE OF ORE AND COST OF TREATMENT

Value of ore:	
21.37 per cent lead	427.4 lb. at \$0.07 per lb. \$29.90 per ton
5.95 per cent copper	119.0 lb. at .25 per lb. 29.75 per ton
8.06 per cent V_2O_5	161.2 lb. at .75 per lb. 120.90 per ton
Total value	\$160.55 per ton
Costs for Treatment by Sulphuric Acid Leach per Ton of Ore:	
1172 lb. of acid at \$30.00 per ton	\$17.50
485 lb. of caustic soda at \$0.04 per lb.	18.40
150 lb. of scrap-iron at \$0.01 per lb.	2.25
Expense for mining, grinding, labor for treatment, depreciation, etc.	15.00
Total	\$52.15
Costs for Treatment by Sulphuric Acid Niter Cake Method:	
2000 lb. niter cake at \$5 per ton	\$9.00
600 lb. acid	5.00
Caustic soda required	18.40
150 lb. scrap-iron at \$0.01 per lb.	2.25
Mining, milling, etc.	15.00
Total	\$49.65

The costs of mining, milling and labor and materials for treatment, depreciation, etc., are variable factors, depending upon the capacity and location of the plant; but it would seem that under the most adverse conditions the cost should not be greater than \$15 per ton of ore.

By reference to the value of the lead and copper present in the original ore, and from the extractions and recoveries considered possible, it would seem justifiable to claim that the return from these, recovered as by-products, would more than pay for the whole treatment of this ore.

Looking at the process from the standpoint of recovering the vanadium only, and assuming a 90 per cent recovery, the value of the product would be:

90 per cent of 161.2 lb., or 144.08 lb., of V_2O_5	\$108.80
Cost of treatment by acid alone	52.15
Cost of treatment by niter-cake acid	49.65

It is evident that this ore would permit an expensive treatment, but, of course, would not warrant it simply for that reason. Even if the costs of treatment, which have been given above, were to be doubled, which would be very unlikely, the methods could still be applied to an ore of this value.

SUMMARY

1. The recovery of the vanadium in cuprodesclowitzite by volatilization in a stream of chlorine or hydrochloric acid gas presents some interesting possibilities, but results obtained were unsatisfactory.

2. The vanadium in this mineral responds more readily to acids than to alkalis.

3. The straight sulphuric-acid leach gives quite satisfactory extractions and permits a good recovery.

4. The niter-cake fusion is undesirable alone but applicable as a preliminary treatment in a combined niter-cake-sulphuric acid process.

5. Copper or other metals undesirable in the iron vanadate must be removed to prevent contamination of the iron vanadate.

6. Boiling of precipitate after neutralization of acid solution is essential to obtain a good grade of iron vanadate.

7. A good grade of iron vanadate can be secured even in the presence of a large excess of iron if the neutralization is carefully controlled.

8. An ore, or concentrate, of the composition of the sample used can be economically treated and possibly at a cost less than the value of the by-products.

I wish to thank Dr. R. B. Moore, under whose direction this work was done, and Dr. S. C. Lind, for many helpful suggestions.

The Edgewood Arsenal

The enlisted men at Edgewood Arsenal, Edgewood, Md., published during the war *Chemical Warfare*. Vol. 1, No. 5, for March, 1919, is a souvenir edition containing the story of Edgewood in text and illustrations. Complete data are given on the production of toxic materials and the filling of shells, grenades, Livens drums and drop bombs. The book contains a wealth of photographs showing the interior equipment of plants, and a complete set of photographs of officers in charge. The book is a credit to the editor in chief and his associates and a fitting tribute to one of the most important branches of the service.

The Oxidation of Ammonia*

Review of the Early Investigations Beginning in 1839 With Kuhlman—Ostwald Process and Apparatus—Improvements Made in Catalyst Screens, Platinum Activation to Foreign Gases Such as Acetylene and Phosphine—Cyanamide Process at Muscle Shoals

By W. S. LANDIS

JUST when ammonia was first intentionally converted into nitric acid or nitrate products I have been unable to learn. Soil bacteria have been doing it for ages. Since the invention of gunpowder, with its increased demand for nitrates, man has endeavored, in places, to assist such bacterial action and thereby lighten his task of recovery. The direct oxidation of ammonia by air through chemical or electrical action seems to have been a scientific curiosity more than a hundred years ago. Eighty years ago Kuhlman, a German technical chemist, after describing at length some very interesting experiments of his own, concluded with the significant remark, "While under present conditions the transformation of ammonia into nitric acid with the assistance of platinum and air has no great value, yet the time will come when it may be of commercial importance."

This commercial prophecy, presented so many years ago, has been a long time reaching fulfillment. Ten years after its utterance, when Chilean nitrate was reaching Hamburg in quantity and prices of nitrate began to decline, its fulfillment must have looked hopeless, as well as during the long years when ammonia prices and nitrate prices were strictly competitive and there was no margin of difference to pay for the transformation. Nevertheless, in the eighty years intervening since the Kuhlman publication, and in spite of the Chilean developments, the Norwegian synthetic nitrate production and the difficult commercial situation, the problem has been attacked in a fairly energetic and persistent manner.

TWO SMALL EUROPEAN PLANTS

At the outbreak of the European war there were two small plants in Europe capable of transforming ammonia into nitric acid, neither of which, however, had shown sufficient commercial possibilities in the five or six years of operation to warrant further expansion. One of the plants was in Germany, but not operating with any regularity, and never had any production capacity to speak of. Not even the military situation had awakened more than a passing interest in the subject in that country. The long-anticipated war was to be short. There were at hand enormous stores of munitions that had been accumulating for a dozen years. The country maintained supplies of over half a million tons of Chilean nitrate at all times, and peace was sure to be dictated within forty or fifty days after the declaration of war. Why should the oxidation of ammonia be of pressing importance?

But to return to our history of development, Kuhlman in 1839 passed a mixture of air and ammonia through a glass tube containing spongy platinum. At ordinary temperatures no action was observed, but when

heated to 300 deg. C. the platinum glowed and with a considerable excess of air in the gas mixture, vapors of nitric and nitrous acids were evolved. At higher temperatures nitrous acid in fairly pure form was obtained. With excess of ammonia the corresponding salts were formed. No quantitative data of any sort were included in the report.

EARLY DISCOVERIES

Eighteen years later the work was taken up by Schonbein, who found that if spongy platinum was saturated with aqua-ammonia and introduced into air, or preferably oxygen gas, slow oxidation to ammonium nitrate took place at ordinary temperatures. Dense platinum caused this oxidation only at higher temperatures. Finely divided nickel and copper also brought about a similar oxidation of ammonia.

Schonbein was probably the first to use dense platinum in the form of wire. He heated a platinum spiral to just below redness and inserted it into a flask which had been rinsed out with a strong ammonia solution. The gas in the flask turned iodide-starch solution blue and the flask filled with a white fog. Powdered copper reacted in the same way.

Passing over the next few years briefly: Tessie du Motay in 1871 obtained nitrates by passing a mixture of air and ammonia over lead manganate, permanganate or bichromate, heated to 350-400 deg. C. Liebig obtained a similar nitrate by using iron oxide. Weith in 1874 mixed ammonia gas with ozone and hydrogen peroxide for direct oxidation. Twenty years later Siemens & Halske took out a patent on the use of ozone for this purpose. In 1912 Jones and his co-workers of the Somet-Solvay, following somewhat the outline of du Motay, developed the oxidation by the use of alkaline earth plumbates. Nothing commercial has come to date from any of the above schemes and a great many others along the same lines not enumerated here.

One more name of importance in this early work is that of Warren, who about 1890 passed an ammonia-oxygen or air mixture over platinized asbestos and obtained ammonium nitrate. Although nothing commercial came directly of his work, its publication undoubtedly assisted in causing the cancellation in the German patent office of the celebrated Ostwald patents, which process I shall refer to next.

THE OSTWALD PROCESS

Twenty-five years ago Wilhelm Ostwald undertook a study of the oxidation of ammonia. He paid much attention to the work of Kuhlman and determined to study the reaction from the scientific standpoint, as nothing along those lines had been done in the fifty years elapsing since Kuhlman's original publication. In his usual careful manner he studied the fundamentals underlying the reaction, and the reading of his exhaust-

*Paper read at the meeting of the American Electrochemical Society in New York, April 3-5, 1919.

ive reports on his investigations would have been of great assistance to many of the recent workers in this field.

Ostwald in general showed the futility of attempting to use spongy platinum as catalytic material, also the necessity of quickly removing the products of the oxidation out of contact with the catalyst. He showed that platinum black was the poorest sort of a catalyzer, yet in spite of this finding, several recent investigators have unsuccessfully attempted to prove otherwise. He noted the activation of dense platinum through operation under special conditions, and particularly the advantage of using such form of catalyst over other types. He further determined the most suitable mixture of air and ammonia for efficient oxidation, and of the utmost importance, that for such mixture a supply of heat above that directly generated by the reaction was necessary for continuous operation.

OSTWALD'S APPARATUS

The result of this work of Ostwald was the building of two oxidation plants of small capacity, the first of which went into operation in 1908. The early apparatus installed underwent several modifications, one of the later type being shown here (Fig. 1).

The exterior tube is of "heat"-resisting and insulating material, and the interior tube of nickel. The

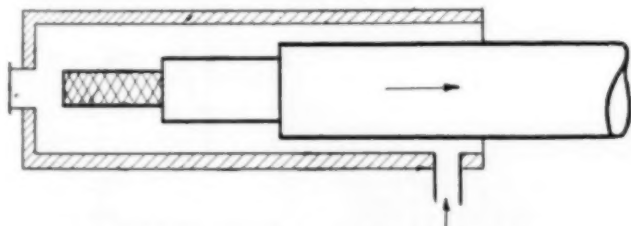


FIG. 1. LATER TYPE OF OSTWALD'S APPARATUS

catalyzer is built up of narrow strips of platinum foil, alternately crimped and flat, thereby producing a series of short tubes. The ammonia gas-air mixture, in the proportions of approximately 10 per cent ammonia, enters the exterior tube at the right, passes to the left in the annular space and out through the red hot catalyzer and nickel tube. This tube is made in sections to enable cheap replacement, as the sections wear unequally. The hot products of combustion lose their contained heat through the nickel tube to the oncoming raw mixture and so serve to keep the apparatus in operation. The apparatus is started by the use of a gas jet at the catalyzer end, or by burning hydrogen gas around the nickel tube. The catalyzer runs very hot, around 800 deg. C.

PROCESS IN ENGLAND

A recent form of somewhat similar construction developed by the Barton interests in England since the outbreak of the war uses a nickel tube about 3 in. in diameter and 10 ft. long. The catalyzer consists of a bundle of spirals of platinum foil hung in the top of the tube. The life of the catalyzer is less than three months. One troy ounce of platinum oxidizes only about 1.5 lb. of ammonia per hr. in this apparatus. The reported efficiency is 90 to 95 per cent, but a study of a large installation in France where cyanamide is converted to ammonia and that to nitric acid shows only 60 to 70 per cent for the whole, and since ammonia production from cyanamide can be carried out at a

nitrogen efficiency of 96 to 98 per cent, depending upon the design of the apparatus and the skill of operation, the oxidation efficiency itself must be very low. I have no direct figures on this catalyzer efficiency.

Ostwald himself reported that his plants obtained an oxidation efficiency of 85 per cent, but my attempts to verify this over long-time operation have been fruitless. I am of the opinion as a result of my investigation that 75 per cent would be nearer. He passed his gas over the platinum at a speed of 5 m. per sec. and left the gas in contact with the catalyzer about 0.004 sec., both figures being far outside the region of our later work, and thereby confirming the low obtained efficiency of his process.

Kaiser, a Siemens & Halske chemist, next attacked the problem. He used a platinum gauze for catalyzer and at times directly heated the air, at times activated it by silent discharge, or preferably both, then added the ammonia and passed the mixture through platinum gauze. The literature on the process is so complex as to be really unintelligible. At any rate he reported an efficiency of 150 to 220 per cent, claiming the activated air enabled the attainment of such a high temperature in the gauze catalyzer as to cause part of the nitrogen content of the activated air to unite directly with oxygen. His work was repeated by Kochman, who reported efficiencies of only 105 to 115 per cent. The answer, we later found, lay in the method of analysis used.

EUROPE'S PREMATURE NOTICE OF ENTERING NITRATE FIELD

In 1908, after the first few cyanamide plants abroad were in operation, the European interests backing them placed the world on notice that they were prepared to enter the nitrate field, which up to that time had been controlled by Chilean nitrate and some small arc-process product. It looks as if this notice was based on the work of Frank and Caro which shortly afterward appeared in the form of patent literature. If so, it was very premature, as that early process never came into commercial development. The process in question used a mixture of cerium and thorium oxides as catalytic material. Like many other processes of like kind using powdered catalyzers, the process failed because the catalyst sintered and became impermeable after short use. Even as late as 1912 work was still being done on this process, the latest development being a catalyzer consisting of 99 per cent ThO_2 and 1 per cent CeO_2 , and showing 65 to 70 per cent efficiency at best.

A COMBINATION PROCESS EVOLVED

The Ostwald patents, after allowance, had been cancelled in Germany and the oxidation process left open to all. Frank and Caro, after the failure of their rare earth catalyzer, turned to a combination process, passing the ammonia-air mixture through a platinum catalyzer, and then through a granular mass of cerium and thorium oxides treated with platinum chloride, and resting on a nickel screen above the platinum gauze. The experiment, carried out in a small apparatus using a gauze 4 in. in diameter, showed efficiencies of from 7 to 78 per cent, with an average of less than 50 per cent.

In July, 1913, attention of the German cyanamide interests was directed to the use of platinum alone as a catalyzer, and the best features of all previous experiments were assembled in a new type of apparatus. The preheating system of Ostwald, with the direct heating, and the gauze of Kaiser, were incorporated in the ap-

paratus shown in Fig. 2. Ammonia could be introduced with the air or at various distances under the gauze. The gauze (1060 meshes per sq.cm. and wire 0.06 mm. diameter) was only 5.5 cm. diameter, not quite all of which was active. From the meager data which came into my possession efficiencies of 41 to 91 per cent were obtained, but as ammonia passing the screen unaltered was not regarded as lost, these figures are subject to 23 to 27 per cent deduction for unaltered ammonia, making actual oxidation efficiency at a maximum only about 65 per cent. Nothing came of this work and in September and October, 1913, a new setup of the same apparatus was made. By regulating the ammonia-air mixture to between 1 : 10 and 1 : 15 by volume an average efficiency of 85 per cent less 6 per cent for unaltered ammonia was obtained.

In November a larger diameter apparatus using a gauze 10 cm. diameter was put into service, but the results were not particularly encouraging, rarely exceeding 80 per cent efficiency and most of them considerably below that figure.

Experiments were carried out with smooth gauze and with gauze coated with platinum black. The latter showed little or no advantage over the smooth platinum, although slightly less ammonia seemed to pass through unchanged. Various alloys of platinum were tried and it was noted that the presence of iridium had a particularly deleterious effect. Further experiments were carried out using multiple gauzes (that is, two and three gauzes superimposed), but in no case were oxidation efficiencies as high as 85 per cent obtained. The combination of multiple gauzes and oxides of cerium and thorium gave lower results than the platinum alone.

The effect of mesh of the gauze was also studied and there was little or no difference noted in the behavior of a gauze with 3000 meshes per sq.cm., as against one with 1060 meshes. Acetylene, and also oxygen, were added to the air, but better results were obtained with air alone than with any of the mixtures, though we later, in this country, obtained different results on enriched air.

EXTERNAL HEAT DECIDED ON

At the conclusion of these experiments, about the end of January, 1914, this investigation on the oxidation of ammonia had not brought out anything of commercial value. The experiments were critically reviewed and it was concluded that the hot gauze radiated heat to the oncoming ammonia-air mixture and decomposed some of the ammonia. This was emphasized by the necessity of preheating the gases before they arrived at the gauze. It seemed necessary to supply external heat in some way to maintain the reaction, and it was, therefore, decided to employ electric energy transformed into heat directly in the gauze itself, to meet this deficiency of energy, and at the same time to use a cooler in front of and in as close contact with the gauze as possible, so as to bring the ammonia in the shortest possible time from the ordinary temperature to the

reacting temperature, which is around 75 deg. C. The apparatus shown in Fig. 3 was constructed to accomplish this result. A long strip of platinum gauze was folded as shown and the intermediate space blocked by mica strips cemented to the gauze. This was placed 1 mm. above a circle of heavy nickel gauze, which in turn was soldered to a water-cooled copper ring. The apparatus was only a few inches in diameter, but it showed very good results, running slightly above 85 per cent in conversion efficiency. It was next duplicated on a larger scale in which the gauze had an area of 660 sq.cm. This apparatus was put into service, but ran only a few hours, when it failed mechanically, and it at no time showed an efficiency of oxidation of above 80 per cent, although the experiments carried out were the most carefully conducted of any performed.

The general program upon which this work was carried out was entirely different from that of similar investigation work as we do it in America. Strange to say, the German experts in charge of it did not seem to devote much time to analysis of the problem from a theoretical or from a physical-chemical standpoint, but instead devoted their attention to the construction of most elaborate and intricate apparatus, in which the principles of chemical engineering were

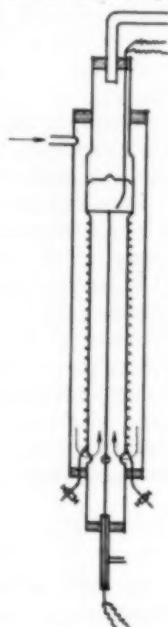


FIG. 2.
OSTWALD-
KAISER
MODIFICATION
APPARATUS

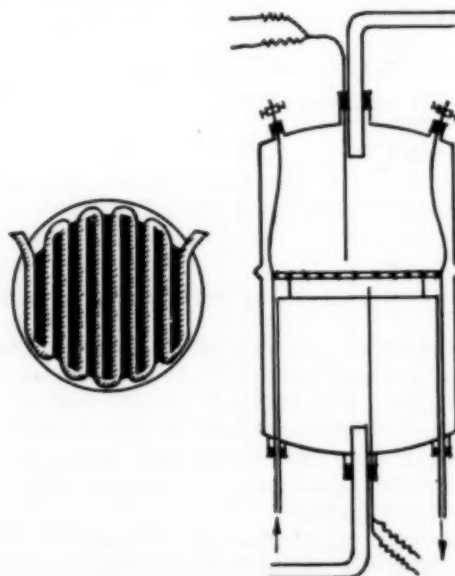


FIG. 3. ELECTRIC HEATED GAUZE APPARATUS

sacrificed to such external details as convenient existing electrical and mechanical conditions. There had not been a cleanout analysis of the problem made, as far as I would find up to the time I left Germany, in November, 1914.

ANOTHER TYPE OF APPARATUS

The construction of a different type of apparatus in which more attention was paid to chemical details next followed. A single sheet of gauze 65 x 25 cm. was especially made for this work, and very great delay in its manufacture was experienced. This gauze was housed in a metal box lined with aluminium, as shown in the detail in Fig. 4. The platinum gauze itself rested upon threads of asbestos, which in turn were carried on a nickel gauze. This nickel gauze was soldered to a frame of copper tubes through which water could be circulated. The apparatus was connected electrically to a source of low-voltage current through a rheostat

and anhydrous ammonia mixed with air was passed upward through the cooler and the gauze.

On Oct. 14, 1914, this apparatus was placed in operation. There was recovered, in the form of nitrates and nitrites, equivalent nitric acid to the extent of approximately 53 per cent of the equivalent ammonia fed to the apparatus. The apparatus failed because the gauze warped away from the cooler in places and this irregular distance resulted in very non-uniform heating. Conditions did not permit my continuing the study of this experimental work, but at the final conference in which I took part I suggested that the whole apparatus

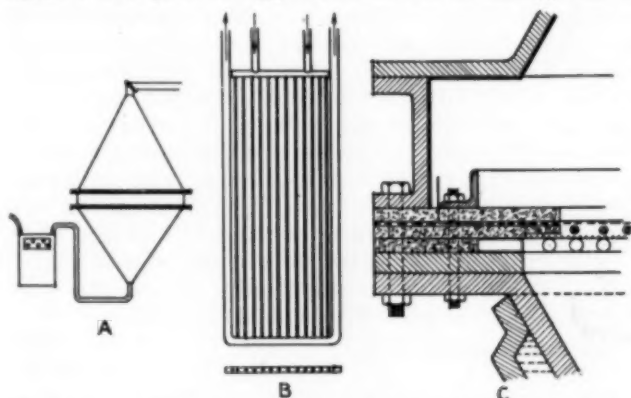


FIG. 4. A. GENERAL ASSEMBLY. B. COPPER WATER COOLER. C. DETAIL OF ASSEMBLY

would operate much better if the coolers as installed were abandoned entirely and the whole catalyzer box turned upside down. This advice was not at the time favorably received, but I believe that later, after my departure from the scene of the experiment, it was adopted and efficiencies of between 80 and 87 per cent were obtained.

This ended my direct contact with this early foreign experimental work on ammonia oxidation. The impressions I received were not encouraging, as I had not seen an apparatus function for more than a few hours at a time. The highest efficiency of conversion of ammonia to nitric oxide obtained in my presence had been only 53 per cent, and no attempt had been made to recover the nitric oxides as nitric acid, but only as nitrate-nitrite.

FURTHER GERMAN DEVELOPMENT

A record of further German development has been difficult to compile. On returning to Berlin I found that the commission in charge of this work had called in a new engineer, one I had not met before, but whom I knew by reputation in nitric acid work. His catalyzer was small, and consisted of a frame of refractory material about 4 in. square and $\frac{1}{4}$ in. thick. Two of these were wrapped with fine platinum wire, very close but not touching, and arranged one over the other so wires crossed at right angles. This gave the gas contact four times with the platinum in a single passage through the apparatus. The frames were arranged in a suitable housing, 24 units to a group. Each unit was supposed to make 230 g. nitric acid per hour, and consumed 4.5 amp. at 90 volts. Mechanically the apparatus was very well designed, but unfortunately it possessed a serious fault in using successive layers of catalyzer not in immediate contact with each other. This arrangement of platinum has never proved satisfactory from an efficient operating standpoint.

The writer is certain that on Jan. 1, 1915, with the

exception of the old Ostwald plant, there had been nothing new erected in Germany for the oxidation of ammonia. A year later, however, very considerable installation of ammonia oxidation plants had been made, and it seems from the strong hands into which the electrically heated catalyzer had fallen that this made the greatest progress. It is believed that by the end of 1915 some form of an electrically heated catalyzer unit had been developed which was oxidizing at the rate of about 15,000 tons of ammonia per year. It is quite possible that this figure was much underestimated. In 1917, it is believed, the ammonia production in Germany had increased to around 300,000 to 400,000 tons, part of which was consumed in fertilizer, part in the direct production of ammonium nitrate and part in the oxidation of ammonia. Just how this division was made I do not know and have made no serious attempt to learn.

During my stay in Germany I found little or no information on the converting of the nitric oxide obtained from a catalyzer into nitric acid. Much of the apparatus proposed was what would be called small-scale work in this country, consisting as it did of towers of chemical stoneware, tourills and such equipment. With such apparatus for condensation, the units must have been small and inefficient, but on the other hand this type of construction lent itself to ease of assembly and a consequent great saving in time of construction. Also much of the nitric oxide was turned directly into sodium nitrate, that being a comparatively simple and easy problem. It further lent itself to the shipment of nitrate to the various powder plants already provided with the old niter pot equipment. In fact it is believed that this conversion to nitrate occurred to a very large extent throughout the war.

IMMINENCE OF WAR AROUSES INTEREST HERE

Toward the end of 1915, when it looked very much as if the trend of events was such that the United States was ultimately to be forced into the war, renewed interest took place in this country in the oxidation of ammonia as a source of nitric acid, and early in 1916 the writer was authorized by the American Cyanamid Co. to proceed with the design and construction of an experimental plant for studying the ammonia oxidation problem along the lines of commercializing what had heretofore been a laboratory curiosity. A considerable latitude in the choice of process was permitted, but it was essential that all equipment to be used must be capable of construction in this country. As to raw materials, we were permitted to make use of any form of ammonia on the market, but naturally we were partial to that produced from cyanamide because of a number of apparent advantages which this form of gas was then believed to possess. I am going to sketch briefly here the method of attack of the problem confronting us, as I believe the details will be of interest.

METHOD OF ATTACK ON PROBLEM

The chemistry of the problem from a quantitative standpoint may be represented by the following equation:



This reaction will take place only in the presence of a suitable catalyzer, of which, from a study of all the previous work, platinum appeared to be the best. It is operative between 700 and 800 deg. C., giving its best results at about 750 deg. C.

The best proportion of air and ammonia for most efficient oxidation was reported by Ostwald to be a mixture containing about 10 per cent of ammonia. He, however, also expressed the opinion that a very large excess of air was advantageous. The small-scale work abroad seemed to show that an 8 per cent mixture was the most efficient to use, and we subsequently confirmed this in our large-scale work. We, however, later learned that the 8 per cent mixture was probably not the most economical for operation and preferred to work with about a 9 per cent concentration.

The combustion of a 10 per cent mixture will yield a theoretical temperature of 665 to 690 deg. C., the difference being due to variations in thermo-chemical constants used in the calculation. Assuming that the catalyzer must operate at around 750 deg. C. and that it will always radiate some heat, it is readily seen that it is absurd to consider attempting to operate the process without the addition of further heat to the catalyzer. With an 8 per cent mixture the temperature of combustion is theoretically only 550 to 580 deg. C.

The reaction



also takes place if the catalyzer is not operating properly, either due to composition or construction, or to other causes. The theoretical temperature of the flame corresponding to this reaction when using a 10 per cent ammonia mixture is 915 deg., using Nernst's data. This is somewhat higher than the actual temperature required on the screen. It is, therefore, seen that it is theoretically possible to operate the catalyzer only if from 25 to 40 per cent of the ammonia carried to the screen is burned to nitrogen, unless one has provided additional heat to the screen supplied either by regenerative methods or derived from an independent outside source.

DETERMINING THE BEST PROCESS

In looking over the methods of supplying this required heat to the catalyzer, the regenerative process of Ostwald demanded heating of the reagents to about 300 deg. C., and as at that temperature ammonia is subject to decomposition, the regeneration process did not look technically sound. We also questioned the control of a self-regenerative system in view of our lack of knowledge of the exactness of this control requirement of the process. The direct heating scheme used by Kaiser required the combustion of additional fuel and seemed to have no apparent advantages of any sort over the Ostwald system. We dismissed his so-called activation of air as of no value.

The only other method that appeared feasible to us was the direct electric heating of the catalyzer itself, and since the energy required is not very great and its cost only a very small fraction of the total operating expenses of the plant, we finally decided to adopt it.

Our next concern was the type of catalyzer. Both Kaiser and Caro had used the woven gauze or screen type with some degree of success, even though many advantages were claimed for the wire-wound frame. We adopted the screen as our first type of catalyzer and designed two forms, one of 80-mesh gauze and 0.0025-in. wire and the other of 100-mesh with wire of 0.0015 in. diameter. This gauze was to be of purest platinum, free from base metals and containing not over 0.05 per cent iridium. Three screens of each type, 13 in. wide and 26 in. long, were obtained from the American Platinum Works. The weaving was not par-

ticularly uniform, and we soon learned that the platinum contained nearly ten times the amount of iridium specified, all of which caused much trouble in the early days of our work.

ELECTRICAL EQUIPMENT

From the specifications of the gauze we figured out our electrical equipment, which was in itself quite an intricate problem in view of the lack of data on electrical conductivities of such materials as platinum gauzes. The current was received at the laboratory at 440 volts, 3 phase, 60 cycles, and distributed at this voltage for motor circuits. A portion was transferred down to 110 volts for lighting and catalyzer service, and to each catalyzer was attached an individual transformer rated 110 v. / 15.0-17.5-20.0-22.5 volts. In the high tension side was included 3 resistance grids with short-circuiting switches and a 25-point rheostat of the same total resistance as a grid. The resistance system was calculated to control the voltage on the low side of the transformer in steps of 0.05 volt over a total range of five volts or two transformer taps. This electrical system was completely revised and both cheapened and simplified in a later installation.



FIG. 5. MODERN CATALYZER UNIT

The catalyzer was housed in an aluminium box rectangular in section. It was stretched in a tray and packed in asbestos board, above which was assembled the sections of the box. We determined to pass the air mixture downward through the hot catalyzer, believing that method to insure more uniform distribution and flow. This necessitated some height of tower over the gauze, and not knowing just how high this should be, we built the housing in sections, each a foot high, making them interchangeable and providing four sections to each catalyzer unit. An assembly of the tower is shown in Fig. 5. Between the upper

sections we placed an aluminium gauze of fine mesh and heavy wire to assist gas distribution, and at the same time carry heat to the side walls, where it was dissipated. The 4-ft. high tower seemed to be just right and has not been changed since the original design, except to eliminate the sectional feature in the later and more permanent installations. The catalyzer trays were all interchangeable and enabled us to repair and change gauzes with very little interruption to operation. After getting into operation we did not find it necessary to complicate the apparatus with a cooler, for while we believe in the use of a proper cooler, we could not design a satisfactory one.

APPARATUS PERFORMS SATISFACTORILY

Besides the oxidation equipment, the plant was equipped with an autoclave and ammonia apparatus for

the production of ammonia from cyanamide, gas holders and most complete measuring and indicating apparatus. Also oxidation, cooling and absorption towers for the recovery of nitric acid. Nothing was left to chance and for our efforts spent on the elaborate design we were amply repaid, for with the exception of the first platinum screens and their terminals, every piece of apparatus installed performed to the highest expected degree.

The first screens being delivered during the erection of the plant, we took one of them to the cyanamide plant in Canada and tried it out there on a small scale, absorbing the products of the reaction in caustic soda. We had learned from Ostwald that activation of the platinum was necessary, but we did not then know what it meant or how to obtain it. After running about two weeks with results showing better each day, we finally, on April 24, 1916, obtained an efficiency of oxidation of 91 per cent. In this series of experiments the highest figure obtained was 92.4 per cent, at a rate of 2 lb. NH_3 per hr. per sq.ft. of screen. The screen used weighed about 1.5 troy ounces per square foot.

While at Niagara the use of enriched air was tried in the mixture, and while it gave very good chemical results, the problem of control was so great that we did nothing to put its use into practice. By its use outside energy can be dispensed with, at least to a very large extent, but the problem of distributing a self-combustible gas over a large area of catalyzer will require more experimentation before it is worked out to a certain war-time surety.

DEMONSTRATION PLANT IN NEW JERSEY

Toward the end of July, 1916, the small demonstration plant at the Ammo-Phos Works of the American Cyanamid Co. at Warners, N. J., was put into operation and it fulfilled our expectations in every way. The very light-weight screens first provided proved themselves structurally too weak for continuous heavy service, and we abandoned their use. As a matter of fact, we later increased the weight of our regular screens about 50 per cent purely for structural reasons. We also found that by passing the gas downward through the converter, only a trace of ammonia passed the screen in its original form. It was either burned or decomposed. We also learned that the capacity of a screen could be increased from the 2 lb. of ammonia per sq.ft. per hr., as obtained in our preliminary work, up to 7 lb. of ammonia per sq.ft. of screen per hr., without greatly affecting the efficiency, and under special test conditions we actually succeeded in operating up to 10 lb. of ammonia per sq.ft. of screen per hr. As a steady operating proposition, however, this latter rate would result in a lowering of the efficiency of oxidation 2 or 3 per cent, and we actually figure for most economical operation, with the high cost of ammonia, 5.5 to 6 lb. per sq.ft. of screen per hr. The highest efficiency attained in all of our development work was 96 per cent, but this was under particularly careful operating conditions at a rate of 5 lb. of ammonia per sq.ft. of screen per hour.

OPERATION OF PLANT SIMPLE

Operation of the plant was comparatively simple after conditions were standardized. Ammonia gas and air were received at constant pressure and fed through meters and valves for mixing. The control of the mixture was a very simple matter and gave no trouble whatever. The screen attendant would turn on the

current to a catalyzer and then feed in the gas mixture at a predetermined rate indicated by an orifice gage on each catalyzer tower. He would then regulate the current so as to obtain the proper temperature, at first measured by pyrometer and later by eye. Two men per shift have operated one hundred catalyzer towers over a considerable period of time, the production of nitric acid during this period averaging one-half ton of 100 per cent equivalent acid per catalyzer per day.

After eliminating the mechanical defects of the early screens we adopted a heavier type, weighing slightly less than $2\frac{1}{2}$ oz. per sq.ft., and we have had some of these screens in service two years continuously on cyanamide-ammonia gas as obtained direct from the autoclave plants and without any purification whatever. These screens seem to be in just as good catalytic condition to-day as when first activated.

LIFE OF THE PLATINUM

The life of the platinum in this process has been the subject of much discussion. Our experience has been that a platinum catalyzer in the ordinary operation of a plant loses between 3 and 5 per cent of its weight per year. Including accidents, it looks as if a screen should give good average service for about one year, at the end of which time it will have lost less than 5 per cent of its weight. It might run longer before being melted, redrawn and rewoven, but we do not have sufficient large-scale experience at our command to give the final answer. In the early days of our experience we had many mechanical accidents and we thought this deterioration of platinum would be considerably greater than the above figures indicate, but on the basis of our experience with the large Government plant, where a very careful check of all platinum was kept, we feel certain at least of the above figures for deterioration and period of renewal. With more skilled operators and higher development of equipment, under conditions more favorable to manufacture than during the war, everything points to a very long life of catalyzer when used on cyanamide-ammonia. Coke-oven ammonia seems to present a different aspect.

VARIOUS CRITICISMS ADVANCED

Several times during the past year there have appeared in print some rather serious criticisms of ammonia derived from cyanamide, particularly in reference to its content of impurities harmful to the platinum catalyzer, as well as to its general application to oxidation. The first published criticism laid the blame on acetylene. Cyanamide-ammonia as obtained directly from the autoclaves which are producing ammonia gas for fertilizer manufacture does contain a very small fraction of 1 per cent of acetylene gas, but we never found any difficulty in oxidizing such acetylene-ammonia mixtures, provided the acetylene content did not get so high that when mixed with air the resulting gas was self-explosive when conducted to a hot catalyzer. The authors of this first criticism, after rushing into print, later found that their conclusions were entirely in error and that it was not acetylene that was causing the trouble. The true cause then became phosphine. They again rushed into print with a second paper showing the evil influence of this phosphine.

Autoclave gas undoubtedly does contain traces of phosphine at times, but the quantity is so small that present-day quantitative methods are unable to detect it with any degree of precision. Having never used any other but such autoclave gas in our laboratory and hav-

ing no trouble whatever with poisoning of the platinum catalyzer, even with screens in use two years, we did not pay very much attention to the matter at first. However, as the criticism of cyanamide-ammonia became a matter of public discussion we thoroughly investigated the whole subject and learned to our surprise that carefully purified autoclave gas, in which it was freed from acetylene, phosphine and other possible impurities, showed consistently about 10 per cent less efficiency on the same screen as when we used the raw gas.

INVESTIGATION SHOWS CURIOUS CONDITION

This was a most curious state of affairs, and after we had firmly established this surprising difference under the most careful control possible, we learned that the platinum catalyzer seems to activate itself slowly to each particular and peculiar gas to which it is subjected during activation and that a catalyzer which had been activated on autoclave gas will not work efficiently on purified autoclave gas or on coke-oven ammonia, but requires a wholly new activation. Left to itself the period of readjustment from one form of activation to another is about ten days to two weeks, whereas our critics were subjecting their catalyzer to ten different kinds of gas on the same day and naturally drawing some very erroneous conclusions. We found a gauze activated on coke-oven ammonia could not be used efficiently on cyanamide-ammonia and that one activated on cyanamide-ammonia could not be used efficiently on coke-oven ammonia, on immediate turn-over, and that it took at least ten days of steady operation on the second variety of gas before the efficiency arose to where it was on the kind of gas on which the catalyzer was activated. We then found on examining the catalyzer closely that there were structural differences in the form which the platinum took when activated with different varieties of ammonia gas.

I have here a slide containing a bit of platinum gauze as received from the weaver and also a piece of gauze which has been in service for some time; the difference on direct vision is quite striking. I have here also a piece of the full-sized catalyzer which has been in service for a long time, showing this effect of activation. Some of our most insistent critics, when thoroughly educated by us to these facts, have later asked to be given ammonia gas high in acetylene and phosphine in the hope that through its use their own impossible apparatus could be made to operate to at least somewhere near the efficiency of our type. It has been most harmful to the progress of the development of the oxidation of ammonia in this country that such individuals as were responsible for the publication referred to above ever interested themselves in the subject. The false information spread broadcast will take much honest endeavor to discredit.

CYANAMIDE PROCESS AT MUSCLE SHOALS

I can only add here that the cyanamide process was installed in the Government nitrate plant at Muscle Shoals, Ala., the whole equipment there embracing 700 catalyzers capable of easily producing, with inexperienced attention, about 250 tons of equivalent 100 per cent nitric acid per day, and which could be pushed, under emergencies and demands, to 50 per cent greater output, or 350 to 375 tons per day, without an extreme sacrifice in efficiency. The autoclave plant transformed cyanamide into ammonia at an efficiency of 97 per cent,

as measured over an extended test under independent Government control.

In this test the plant was operated by men, part of whom had been trained in the American Cyanamid Co.'s experimental plant, but the chemical control was entirely exercised by Government chemists. The catalyzer efficiency for all catalyzers over this same period of time was 91.5 per cent. The absorption efficiency to the production of nitric acid was 98 per cent. This is equivalent to a total efficiency from cyanamide to nitric acid of 87 per cent, and of ammonia gas to nitric acid of practically 90 per cent. With more experienced operators, undoubtedly these figures would have been raised several per cent in the next six months. The figures are certainly a direct contradiction of a statement of some of our critics that cyanamide-ammonia cannot be oxidized at any high degree of efficiency because of its impurities. As a further matter of interest, the power requirement of the process, as installed, averaged less than 1.7 kw-hr. per lb. of nitric acid made on the catalyzer.

The gases leave the catalyzer at practically redness, although attempts are made to radiate as much heat as possible. They enter flues under the floor and are carried to coolers, where their temperature is brought down to as near normal as possible. They then pass into oxidation chambers, where a minute or two of rest converts practically all of the nitric oxide to nitrogen dioxide. This passes into absorption towers, where oxidation to nitric acid takes place and the acid is absorbed in water. Due to high concentration of nitric oxide gases, the efficiency of recovery in our absorption system is very high. In the Government plant it averaged above 98 per cent and frequently ran for long periods of time at 99 per cent. All absorption was done in water and no soda towers were used in the system whatever. The strength of acid obtained could be run as high as 50 per cent or even more, but as the material was to be used for making ammonium nitrate, no attempts at obtaining extreme concentrations were made. Since this nitric acid is extremely pure, circulation through aluminium pipes is entirely feasible and possible, and its handling with this facility at our disposal was a simple problem.

As to the cyanamide-oxidation process, it does not lend itself as readily to very small-scale installations as the old niter pot, because of the cost of installation, but where ammonia gas is available and it is not necessary to provide separate ammonia equipment, even in this case it will find some very interesting uses. For instance, at the Ammo-Phos Works of the American Cyanamid Co., a catalyzer operating on ammonia gas is supplying nitrogen oxides direct into a sulphuric acid chamber plant with very great success and at very good economy over the old potting process. Not only are the nitrogen oxides much cheaper than when made from nitrate of soda, but the consumption is very much less and the control of the chamber plant very much simplified.

COST OF OXIDATION PROCESS NOT HIGH

With ammonia gas of suitable quality obtainable at no higher unit price than equivalent nitrogen in nitrate of soda and on a reasonably large operating scale, the oxidation process will make concentrated nitric acid for at least as low a cost as the niter pot and on a large scale at a lower cost. The cost of the plant is somewhat more than for a similar sized pot plant, but

the consumption of raw materials and of labor, and the ease of manipulation, all greatly favor the ammonia oxidation plant, and it is quite likely that where the size of the installation is sufficiently great, it will offer a very serious competitor of the old nitrate of soda process.

On a fair sized plant, the operation, concentration, overhead, taxes, interest and depreciation will amount to approximately one-third of the cost of concentrated nitric acid, but this can only be accepted as a most general figure, because each plant and location must be studied individually, as these factors exert a very considerable influence on the total cost of the product. It must further be remembered that not all varieties of ammonia have shown themselves capable of oxidation. The Muscle Shoals plant furnished some rather interesting data on the cost of nitric acid and ammonium nitrate, the factory cost on the latter being less than one-half of the Government fixed price, from such figures as were obtained during the short period of partial operation of that plant. The cyanamide oxidation process has been fully protected by patents and its development and installation are still wholly in the hands of the American Cyanamid Co.

CONCLUSION

In conclusion, the early prophecy of Kuhlman is about to be fulfilled, and large consumers of nitric acid will do well to look closely to the oxidation of ammonia in planning their future extensions. As a war-time emergency the development in all the warring countries has given us a direct answer to its practicability. Without it Germany would not have lasted a full year of modern warfare, and the Allies themselves were forced to come to it, even with Chile open to them. When coupled with the fixation processes, its saving in transportation, raw materials, sulphuric acid, and its adaptability to large-scale units places it far ahead of the older nitric acid process, and for certain special applications it has no competitor. It was a long time coming to the front, but I believe it has now reached the point where future extensions and improvements will be rapid, and I anticipate it will soon be producing its better product alongside its older competitor on a fair-sized scale.

Lead Poisoning

THE susceptibility of women workers in lead industries to certain forms of lead poisoning and the dangerous effects of this occupational poison on their children are two important facts brought out in a bulletin on Women in the Lead Industry (Bulletin No. 253) just issued by the Bureau of Labor Statistics of the U. S. Department of Labor. Lead, which is by far the most common industrial poison, is responsible for no less than 95 per cent of all the poisoning due to occupation, according to Teleky, a German authority. In this country lead poisoning is a fairly familiar occurrence, but until comparatively recent times it has not been at all common among women workers because relatively few women have been employed in lead industries. Now, however, women are beginning to enter occupations in which exposure to lead is inevitable, and it is regarded as very important to look carefully into the question of their employment in such occupations and to determine whether it will be better to safeguard them by requiring employers to use every known means to reduce

or eliminate the hazard of lead poisoning or by prohibiting the employment of women entirely in those occupations in which lead poisoning constitutes a considerable hazard.

British authorities hold that women are more susceptible to poisoning by lead than men, and legislation in Great Britain has followed these authorities, with the result that women are barred from some of the most dangerous lead work. On the other hand, the Germans believe that the apparently greater susceptibility of women to lead poisoning is to be explained not by their sex, but by the fact that they are usually more poverty-stricken than the men, are undernourished and obliged to do work for their families in addition to their factory work. Observations in the pottery industry in this country seem to bear out the German theory, for while a much larger proportion of women than of men were found suffering from lead poisoning in the East Liverpool and Trenton districts, it was also found that in these districts the men are members of a strong union, are well paid, and have good living conditions, while the women are unorganized, underpaid, poorly housed, poorly fed, and subject to the worry and strain of supporting dependents on low wages. In the unorganized pottery fields, in the tile works, and in the art potteries of the Zanesville district the men and women were in the same economic class, all making low wages, with everything which that implies, and here the rate of lead poisoning was slightly greater among the men.

Whether or not women are more susceptible to lead poisoning than men, the records show that they are more likely to have the nervous form of lead poisoning than are men. Women suffer more from lead convulsions and lead blindness, men from lead paralysis and lead colic.

The report points out that "women who suffer from lead poisoning are more likely to be sterile and to have miscarriages and stillbirths than are women not exposed to lead. If they bear living children these are more likely to die during the first year of life than are the children of women who have never been exposed to lead." Striking proof of this fact is contained in the bulletin. "Everyone will admit that a poison which may destroy or cripple a woman's children is a far more dangerous poison than one which only injures the woman herself. This is why it is necessary to forbid the entrance of women into the more dangerous kinds of lead work and to surround their employment in the less dangerous ones with all possible precautions," says the bulletin.

The bulletin opens with a brief description of lead poisoning, noting some of the well-known symptoms by which it is easily recognized, but calling attention as well to symptoms which are less clear and which prompt the statement that "there is no known poisonous substance which can give rise to such a variety of symptoms as lead." A number of typical cases are briefly described. An important fact brought out in the discussion of lead poisoning is the difference in susceptibility of workers. For example, in one white lead factory the records show that one of the employees began to feel symptoms of lead poisoning at the end of two weeks' time, and died after five and a half months. In the same factory was a man who had worked in clouds of white lead dust for 32 years, ever since he was a boy of 12, and had felt no ill effects.

Flaky Fractures and Their Possible Elimination

A Critical Review of the Literature Bearing Upon Oxides and Other Inclusions in Steel, Together With an Application of the Principles of Physical Chemistry to Conditions in a Steel Melt—Deductions of Technical Importance Are Drawn Which Where Applied Reduced Failures

BY HAAKON STYRI

IN CONNECTION with the hypothesis that flakes are largely due to non-metallic inclusions, it is of interest to review in part the previous work of other investigators concerning inclusions and crackings in steel.

Capt. H. G. Howarth,¹ on examining fractures, found inclusions sometimes visible to the naked eye, but often so small that a handglass or microscope had to be used for detection. The color varied from sulphur-yellow to green, or to cream and bronze, and they sometimes covered 10 per cent of the area. They were mostly elongated, but had also irregular shapes. Laminated fracture and a small reduction of area with external cracks in the specimen were associated with them. They were more common in large than in small forgings, which were reduced from 1 to 5, and were mostly found in the bottom end of large ingots, while the streaks were always placed longitudinally. He had not been able to detect a single greenish defect in longitudinal tests. He notes the optical similarity of detached pieces of the slag particles from the fractures to manganese silicate slag.

Stead in discussing the above paper mentioned the reaction between silicon, manganese and oxygen and gave the following analysis of a residue from dissolving steel in dilute HNO_3 : SiO_2 , 46.6; MnO , 48.08; Al_2O_3 , 3.39; FeO , etc., 1.92.

Fay² shows that MnS causes a fibrous structure in fractures and gives an example of a 12-in. rifle where this had caused fracture during service in spite of excellent heat treatment.

E. F. Law³ discusses the different forms of "non-metallic impurities" and advocates the necessity of proving by analysis whether or not silicon and manganese are present as oxides, and gives examples of blister sheets where those with high oxygen have the poorest properties.

J. E. Stead⁴ found on welding blowholes and cavities in ingots that for complete welding the surfaces must be in actual contact at a temperature above 950 deg. C. (and preferably at least 1100) and that disruption can be caused by faulty forging. Morgan said in discussion that surfaces or blowholes would not necessarily come in contact during mechanical work: they may only be distorted. Stead remarked later that segregations of S (MnS) may cause premature fracture on transverse test even when blowholes were perfectly welded, and that FeO does not prevent welding in certain cases where sufficient carbon is present, because the oxygen can be consumed in decarbonizing the surrounding material.

Rogers⁵ shows the presence and influence of MnS in fractures by means of a gelatine emulsion of silver bromide.

J. N. Kilby⁶ gives two causes for "oxides" in steel melting: they are formed during melting and not removed, or they are introduced by excessive or erratic feeding of ore. He advocates having as high as 2 per cent silicon in the total charge from the start, and the using of limestone to reduce the amount of FeO in the slag, thereby increasing the manganese yield. Slag with CaO will act as a better absorbent of extraneous matter existing in steel and thus minimize the oxidation of manganese. When slag is added to the charge it will protect the bath from oxidation. The hearth condition is important in the acid open-hearth process, whether the hearth is saturated with oxides or not. He also gives evidence that teaming at a correct rate is necessary to prevent the ingots from cracking.

McWilliam and Hatfield⁷ in a paper on the elimination of silicon in acid open-hearth show how the amount of silicon in steel corresponds in general to the amount of silica in the slag at normal bath temperatures.

Boylston,⁸ studying the relative merits of various agents for deoxidation of steel, comes to the conclusion that no startling difference is noticeable in their action.

J. E. Howard,⁹ discussing sound steel ingots, mentions the impossibility of welding across inclusions and the consequent defects from rolling them into streaks, forming laminations and causing danger in transverse tests. Petinot, in the discussion, also noted the danger from oxidation products of aluminium and silicon, and says the use of titanium is less dangerous because the TiO_2 formed will help flux the other slag inclusions provided sufficient time is given in the ladle. With less inclusions to contaminate the surface of the pipe, this will be easier to weld. Zimmerschied listed defects in automobile steels, increasing in importance to the last—ingotism, seaminess, pipes, segregates, non-metallic inclusions—while Dudley said segregation is decidedly reduced with ferrotitanium, and is not so marked with silicon.

Hibbard¹⁰ considers the distribution of solid non-metallic impurities in steel to be important; they are dangerous if present as pellicles in the crystal joints even if the total amount is small, and the influence of the impurities is most important during hot work, because they make the steel brittle. He cites a case¹¹

¹Journal, Iron and Steel Institute, 1905, p. 301.

²Proc., American Institute for Testing Materials, 1908.

³Journal, Iron and Steel Institute, 1907, p. 94.

⁴Journal, Iron and Steel Institute, 1911, I; p. 54 and p. 104.

⁵Journal, Iron and Steel Institute, 192, I; p. 379.

⁶Journal, Iron and Steel Institute, 1907, II; p. 69; 1918, p. 365.

⁷Journal, Iron and Steel Institute, 1902, I; p. 54; 1904, II, p. 206.

⁸Carnegie Scholarship Memoirs, 1916, p. 102.

⁹Trans., American Institute of Mining Engineers, 1913, I, p. 490 et seq.

¹⁰Trans., American Institute of Mining Engineers, 1911, p. 321.

¹¹Revue de Metallurgie, 1912, p. 1103.

where improvement in spring steel was obtained by adding pig iron to the melt and letting it boil, and says that agitation is of little use if the inclusions do not coalesce, for which time must be given. The particles in the bottom of an ingot do not get time to assemble before the freezing of the steel.

Rosenhain,¹³ in reviewing the subject of inclusions for the International Congress for Testing Materials, says that the fundamental question of solubility of slags in steel is not solved, and refers to Hibbard's conclusion that inclusions are due to a combination of the purifiers manganese and silicon with oxygen sulphur and to Stead's idea that oxygen is taken up by steel on passage through air in pouring. He proposes attempting to coalesce small globules of slag in a manner related to the glassmakers' practice of introducing a moist potato in the melt to produce large gas bubbles. He also mentions banding in plates as being due to ferrite crystallization on elongated foreign particles and compares this with the persistence of inclusions in ferrite bands in welds.

Stead¹⁴ showed how a coarse network of inclusions persisted after heat treatment which destroyed the primitive ferrite network, while Portevin and Bernard¹⁵ gave an example of a coarse ferrite network containing small holes with consequent brittleness persisting after quenching in water at 850 deg. C. and drawing to 700 deg. C.

Ziegler¹⁶ cites evidence for the idea that inclusions serve as crystallization centers for alpha ferrite.

Stead¹⁷ argued that inclusions alone do not act as crystallization centers for ferrite. Ferrite streaks result rather from an unequal phosphorus distribution during the freezing of the ingot, incidentally associated with inclusions enveloping the primary crystals and worked into streaks by mechanical treatment. Phosphorus can be evenly distributed by prolonged heating above 1200 deg. C. Brearley, in discussing, said that intimate contact must be necessary to induce ferrite crystallization on foreign particles, and Rosenhain remarked that nuclei must be isomorphous to iron to induce such crystallization.

N. J. Belaiew¹⁸ says that the macrostructure of a specimen of steel is a result of nonhomogeneity in chemical composition of crystals solidifying at different points. Therefore it cannot be changed by ordinary treatment—mechanical work will only distort, and temperature, if high enough, will only produce local change within the macrocrystal.

F. Robin¹⁹ believes cracking is mostly due to foreign matter or small cavities, since his experiments showed the most fissure-formation in unclean steel. He also observes that fissures formed in spite of expert forging followed inclusions. By forging nickel steel (Ni 2.5%, Cr 1.5%, C 0.5%) at 1100 deg. C. he produced fissures which did not follow martensite lines.

Portevin and Bernard,²⁰ in discussing the interrelation between mechanical properties and Widmanstätten structure, show how W-bands and martensite are related, and give in some shock tests an example of poor quality of steel where ferrite is partly left in Wid-

manstätten structure after forging, and how heat treatment can improve this. Belaiew noted that certain Russian artillery contracts include a paragraph that forgings may be rejected if Widmanstätten structure can be found at a magnification of 50.

G. Charpy²¹ describes experiments to show the uneven amount of work the particles in an ingot get in forgings as compared with rolling. He says on test-pieces taken from forgings on transverse planes with different amount of reduction that "there is a dominant reason to forego comparison of such test-pieces owing to the variations in composition and in structure which are inevitable in transverse sections of any ingot." He shows further how the elongation and reduction in area of transverse test-pieces are reduced with an increasing amount of reduction in work when compared with corresponding properties of longitudinal test pieces, and remarks that this difference will increase very much with an increased amount of impurities. Impact tests showed the influence of the direction of the fracture to the direction of the rolling, with the best results where the stress is parallel to the direction of work.

H. M. Howe²² in discussing dull porcellanic fibrous fractures, remarks that lengthwise banding of ferrite accompanies fibrous fractures and offers itself as their natural cause. Furthermore, they are ultimately due to slag in steel of plastic origin; but in steel from liquid origin are due to dendritic segregations (including carbon, phosphorus, manganese, slag and blow-holes) drawn out lengthwise in rolling and forging.

A. McCance²³ estimates that fully 90 per cent of the failures he has noticed are due to nonmetallic inclusions. Steel which is heat-treated to brittleness starts cracking from such inclusions, but this effect is negligible in steels with proper heat treatment, although inclusions in groups are detrimental. He calls attention to Inglis' work²⁴ showing that stresses existing in metal surrounding holes are not equally distributed, but are greatest at the end of the axis, which is normal to the direction of pull. Proximate calculation shows that small particles cannot rise to the surface in the time given for ingot solidification. Viscosity of the steel is also an important factor, and therefore he advocates a high tapping temperature. Brinell, Hachney and Stead believe that different amounts of manganese are necessary to take care of the sulphur in steel, while Röhl²⁵ notes that MnS is insoluble in steel; consequently McCance says it is unlikely that FeS is not completely reduced by manganese.

Steinberg,²⁶ however, shows that artificial inclusions of sulphides in steels will distribute equally on freezing from the liquid and grow smaller on quenching from high temperature, therefore some sulphur must go into solution even before fusion. McCance also gives an experiment on Al₂S₃ artificially placed in steel, which shows some reaction, since the steel was welded across the sulphide inclusion.

McCance further states that there is a relation between the heats of formation of the oxides and the degree to which they can be reduced, and quotes Levy's²⁷ experiment, placing slag (2MnOSiO₂) in contact for 30

¹³*Revue de Metallurgie*, 1912, p. 988.

¹⁴*Journal, Iron and Steel Institute*; 1905, II, p. 84.

¹⁵*Revue de Metallurgie*, 1915, p. 155.

¹⁶*Revue de Metallurgie*, Sept., 1911.

¹⁷*Journal, Iron and Steel Institute*, 1918, p. 287.

¹⁸*Revue de Metallurgie*, 1917.

¹⁹*Revue de Metallurgie*, 1911, p. 436.

²⁰*Revue de Metallurgie*, 1912, p. 544.

²¹*Engineering*, 1918, p. 310.

²²"The Metallography of Steel and Cast Iron," pp. 539, 546.

²³*Journal, Iron and Steel Institute*, 1918, p. 239.

²⁴*Proc., Institute of Naval Architects*, 1910.

²⁵*Carnegie Scholarship Memoirs*, 1912.

²⁶*Revue de Metallurgie*, Extracts, 1914, p. 313.

²⁷*Carnegie Scholarship Memoirs*, 1911.

min. with siliceous cast iron, with the result that manganese increased in the iron, and SiO_2 increased in the slag $\frac{1}{2}$ to $\frac{3}{4}$ in quantity. Slag in contact with steel and the inclusions will ultimately be converted into manganese silicate. The loss of manganese in acid open-hearth practice is due to a reduction of FeO by manganese. He emphasizes the influence of slag constitution and temperature on the ease of elimination of impurities, giving an example of how greater fluidity improves the steel. (He apparently means, however, that boiling in the bath will cause slag particles to mix into the steel, for the same reason that steel globules are found in the slag, but only the latter occurrence can be normal, since boiling gives an upward movement of gas bubbles.) He says further that oxidation of carbon can only take place when silicon and manganese have been reduced to traces, while the solubility of FeO in steel must be independent of outside pressure, in spite of his reference to Baraduc-Muller,²⁸ that CO (and hydrogen) are given off under reduced pressure.

The many authors cited above do not use the term "flake"; but it is evident to the student that the causes of failures in the steels which they have investigated are often similar to those which have caused flaky fractures of steels described in the first portion of this paper. In this experimental work the author has come to the conclusion that the predominant cause for flakes is nonmetallic inclusions, which will be the more dangerous the larger the area they present at right angles to the direction of stress and the sharper they cut.

Flakes may also be caused by incipient cracks formed through faulty pouring, heating or forging, which by the way, are more easily formed when inclusions are present. In general, the high elastic limit and tensile strength in rejected testbars indicate that inclusions and incipient cracks ordinarily are only spots from which the irregularity in the fracture (flakes) propagates during testing. Blowholes and segregation may occasionally cause flakes.

Since no distinct microstructure has been found associated with flakes, the heat treatment generally given to commercial steel will not cause flakes, nor can it eliminate them; but proper heat treatment will of course improve the physical qualities of the sound portions of flaky steel and lessen the tendency to crack formation.

With the principal causes for flakes and corresponding failures identified it will now be proper to discuss the factors that will influence their elimination.

EQUILIBRIUM OF OXIDES IN IRON

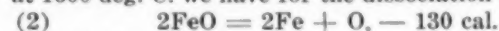
We know from the many researches on inclusions that they are oxides, silicates and sulphides. They are probably in general not inclusions of the same composition as the furnace or ladle slag. Sulphides are sometimes identified and in exceptional cases, when quantitative analysis can be made, the difference in composition is shown as in the above stated by Stead and in another, furnished the author by party F, which gives SiO_2 41.8, Fe_2O_3 1.8, Al_2O_3 17.15, MnO 29.3, CaO 0.5, MgO 0.54, with the ordinary slag SiO_2 51.4, Fe_2O_3 22.2, MnO 19.9, CaO 3.1. For many cases, examined in the first part of this paper, different kinds of particles were found in the same fracture.

Inclusions may have been caused mechanically in tapping a pouring, but ordinarily inherent conditions in the molten steel is the cause. A very good idea of

the formation of the inclusions may be had if we utilize in part H. Le Chatelier's admirable treatise on the application of pure science to metallurgy,²⁹ a work which is hardly known in English literature. Le Chatelier arrived at the basic principle for the reduction of oxides by applying the dissociation law. Thus the partial pressure of oxygen as it varies with the temperature can be calculated by means of Carnot-Clapeyron's formula applying to simple reactions:

$$(1) \quad -\frac{L}{T} + 0.002 \ln P = 0.032$$

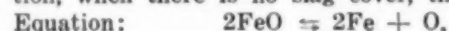
where L is the heat of the reaction, T the absolute temperature, and P the dissociation pressure. Thus at 1600 deg. C. we have for the dissociation of iron oxide



Substituting in equation (1)

$$\begin{aligned} -\frac{-130}{1873} + 0.002 \ln P &= 0.032 & \text{whence} \\ \ln P &= -18.7 & \text{or} & \log. P = -8 \\ P &= 10^{-8} \end{aligned}$$

which as noted above is the partial pressure of the oxygen in c.g.s. units for free iron oxide at 1600 deg. C. In a saturated solution of iron oxide in steel at 1600 deg. C., with a hypothetical cover of FeO and where equilibrium exists, the partial pressure of the oxygen in solution must be equal to the dissociation pressure of free iron oxide at the same temperature. If less oxygen than corresponding to saturation is dissolved in the steel, some more FeO from the slag will go in solution. Utilizing the law of mass action, one can find the partial pressure of the oxygen at concentration less than saturation, when there is no slag cover, thus:



Concentrations: $a \quad b \quad p$

$$(3) \quad \frac{a^2}{b^2 p} = \frac{1}{k} \text{ where } k \text{ is a constant.}$$

b may be considered equal to 1, since the concentration of iron varies but little, then

$$(4) \quad p = ka^2$$

and at saturation

$$(5) \quad P = kA^2$$

Le Chatelier gives the solubility of FeO in steel at 1600 deg. C. as 1.1 per cent (equivalent to 0.244 per cent O), while P has been already calculated to be 10^{-8} . Dividing (4) by (5)

$$\frac{p}{P} = \frac{a^2}{A^2}$$

Substituting known values and letting the concentration of FeO represent the concentration of O since it makes no difference mathematically and facilitates the following calculation:

$$(6) \quad p = \frac{10^{-8}}{0.244^2} a^2$$

From this equation the partial pressure of different concentrations of oxygen in steel can be calculated. If the metal is in contact with a slag of another composition than pure FeO , which is the condition assumed in deriving the above equation, the equilibrium would demand less amount of oxygen in the steel (less oxygen pressure) even disregarding the influence of the heat of reaction between FeO and other components of the slag, because of the lower concentration of FeO in the slag, and it should be possible in practice to arrive at the oxygen pressure at equilibrium, at least numerically,

²⁸Carnegie Scholarship Memoirs, 1914, p. 216.

²⁹Revue de Metallurgie, 1912; "La Silice," p. 558.

by analyzing for oxygen in steel and the corresponding slag of ferrous or complex silicates. Pickard¹⁸ and Schirmer Kichline¹⁹ therefore do not give the maximum solubility of oxygen in steel, when they state 0.092 per cent O present, but possibly the equilibrium for their particular slags, of which analyses were not given.

To find the influence of an addition of manganese to the bath at 1600 deg. C. we will further with Le Châtelier consider the equation



Cone. $\frac{c}{d^2e} = \frac{1}{k_1}$
Substituting in equation (1) and solving,

$$E = 10^{-14}$$

which is the dissociation pressure for free manganese oxide.

By the law of mass action

$$(7) \quad \frac{c^2}{d^2e} = \frac{1}{k_1}$$

In equation (7) d , the concentration of manganese in the steel under a manganiferous slag, can be varied and e , the concentration of MnO in the slag, can be considered maintained constantly equal to unity. Hence

$$(8) \quad e = \frac{k_1}{d^2}$$

In case there is no iron in the metal, that is, for pure manganese, $d = 1$; equation (8) further simplifies into

$$(9) \quad E = k_1$$

$$(10) \quad e = \frac{10^{-14}}{d^2}$$

That is to say, the dissociation pressure of manganese oxide in the steel, or in other words the partial pressure of O dissolved, varies inversely as the square of the concentration of manganese in the steel.

It is now easy to show graphically how manganese and oxygen will influence one another when dissolved in steel. For this purpose Curve I in the accompanying

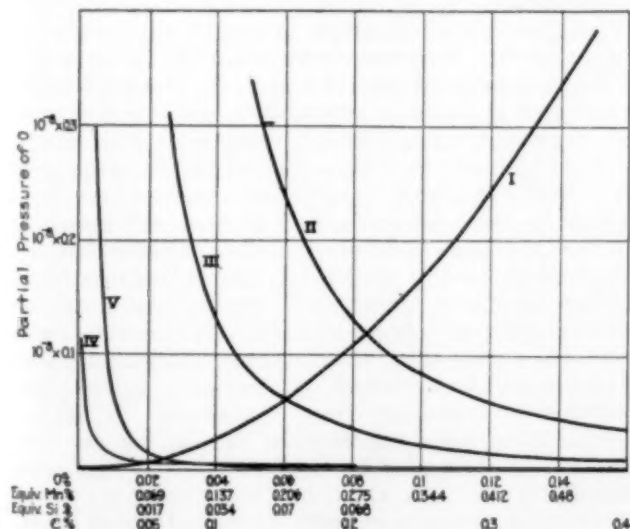


chart has been calculated by the author after formula (6), giving the oxygen pressure for different concentrations of O in steel, and Curve II after formula (10) for the partial pressure of the oxygen which can be in equilibrium with different concentrations of manganese in steel. (The abscissæ give the manganese equivalent of oxygen to facilitate graphic calculation; equal

horizontal lengths will give the amount of manganese necessary for the reduction of oxygen.)

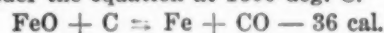
If we change the concentration of MnO in the slag and disregard the influence of the heat of reaction between MnO and other components, we can see from equation (7) that the oxygen pressure and accordingly the concentration of oxygen must decrease with the square of the concentration of MnO in the slag for equilibrium. Curve III is therefore calculated for 50 molecular per cent MnO in the slag.

For silicon a similar calculation may be made to that for manganese, noting that the heat of the reaction at 1600 deg. C. is 180 cal. The result is

$$(11) \quad h = \frac{10^{-13.7}}{g}$$

where h is the dissociation pressure (or partial pressure of oxygen) of silica and g is the concentration of silicon in the steel, and the two are inversely proportional to each other. Curve IV is calculated for the partial pressure of oxygen in the bath which is in equilibrium with varying amounts of silicon, and as before the silicon equivalent of oxygen is noted on the horizontal axis.

Further, consider the equation at 1600 deg. C.



Concentrations: $i \quad j \quad m \quad n$

By equation (1)

$$n = 10^{2.78} = 600 \text{ atmospheres}$$

the pressure of CO in equilibrium with FeO, carbon and iron.

Generally when iron oxide is reduced by carbon CO, will be found simultaneously with CO in amounts varying little with the temperature at about $\frac{1}{3}$ the total. The solubility of carbon in steel at 1600 deg. C. is given by Le Châtelier at approximately 5.5 per cent, and of oxygen 0.244 per cent, and both can be present simultaneously at this concentration if the total gas pressure ($\text{CO} + \text{CO}_2$) is 870 atmospheres. Substituting these values in the mass-action equation, and letting m equal unity

$$K_3 = \frac{ij}{mn} = \frac{0.244 \times 5.5}{600}$$

For the total gas pressure $\text{CO} + \text{CO}_2 = 1$ atmosphere, the partial pressure of CO is equal to 0.7 atmosphere, and we can calculate the concentration of oxygen and the corresponding oxygen pressure of the CO in steel for different amounts of carbon, as represented by Curve V, since the oxygen-pressure of CO and of FeO must be equal at equilibrium. The abscissæ in this case are chosen to make the amounts of carbon most commonly found in the bath come within the limits of the chart. If the gases CO and CO_2 should need a higher pressure than 1 atmosphere to escape from the bath, the ordinates of Curve V would be correspondingly higher. On the other hand, if we introduce another gas in the steel, for instance, by poling, we facilitate the formation of CO and CO_2 since they do not then alone carry the whole atmospheric pressure + the hydrostatic pressure of the steel above.

PRACTICAL DEDUCTIONS FROM THE CURVES

The chart tells clearly that manganese alone is a comparatively weak deoxidizer, but has a much stronger action if some other deoxidizer like silicon is present. This for the reason that the MnO formed will then combine with the SiO_2 formed simultaneously, thus re-

¹⁸Carnegie Scholarship Memoirs, 1916, p. 74.

¹⁹Trans., American Institute of Mining Engineers, 1913, p. 426.

ducing the concentration of both MnO and SiO_2 in the slag, whereby in turn the deoxidizing power of the metals is increased. There is the further advantage of adding manganese and silicon to the bath together, since the resulting slag will be more fluid and it can more easily combine into larger drops and rise to the surface. Any other addition of deoxidizer which forms an oxide which will combine to a more fluid slag will be of advantage.

We see further from the chart that carbon is a stronger deoxidizer than manganese, and weaker than silicon for low concentrations but stronger at higher concentrations. The numerical values of the chart must of course be considered with reserve since so little experimental work has been done along this line. This will explain why silicon under certain conditions can be reduced back into the bath.

The chart represents only the conditions at 1600 deg. C. To calculate for other temperatures, one would have to know the corresponding solubilities of oxygen and carbon. In general, we know from the formula given above that the dissociation pressures of the metallic oxides increase with temperature and also from v. Juptner's calculations¹ that the dissociation of CO changes little with temperature.

It is easy now to understand how the strong reducing power of carbon can be utilized to advantage in refining steel. In the melting-down period when the temperature is low, oxygen will principally combine with silicon and manganese to form small slag globuli in the bath. After the bath is liquid, as the temperature increases, the oxygen pressure of these oxides will increase, with the result that carbon will gradually get a stronger reducing action on them. CO will be formed and the bath commence to boil, with the consequence that the small gas bubbles drive the nonreduced slag particles with them up through the steel just like drops of rain take dust particles out of the air. For this reason boiling must be considered the best method of purifying steel, and more so in nickel than in carbon-steel, since the viscosity of the former is higher, and therefore the slag particles included will have the more difficulty in liquating and rising to the surface. It is wrong to "kill" the boil by introducing the ordinary deoxidizers manganese and silicon, because the very oxides are then formed which we want to eliminate. On the other hand, boiling should not continue until the carbon gets too low, with the result that oxygen would be taken from the slag (which in open-hearth practice is always to some extent oxidizing), necessitating in turn the addition of more deoxidizer to properly kill the steel before tapping if time cannot be given to deoxidize with wash metal. Boiling should be diminished toward the end so that only the amount of alloys should be added which is necessary to prevent gas-evolution upon solidification. If no deoxidizers are added the gradual concentration of carbon and oxygen toward the center of the ingot during the solidification period would otherwise cause such gas-evolution.

Oxidation products are not the only foreign impurities in steel. They also come from the slag and from small particles in spouts, runners, ladles and molds, which should all be kept strictly clean. Other sources, much worse, have come to the author's notice; for instance, the throw of lime with the stream of steel in the ladle in order to get a thick slag cover.

Only few words need to be said about the other main impurity in steel—sulphur—since the reactions between it and iron, manganese and aluminium are exactly similar to the reactions between oxygen and iron, manganese and silicon. But for the lack of some experimental data a chart like the one given here could be calculated for sulphur, and it would show how desulphurization (sulphur pressure) would depend on the heat of reaction of the sulphides. It is incorrect to say that MnS is insoluble in steel. MnS will dissolve until the "solubility product" of manganese and sulphur prevents further solution, a point which of course is different in solid and liquid steel. The same holds true for Al_2S_3 , explaining how McCance found Al_2S_3 distributed in steel after forging.

CASTING PRACTICE

Casting of the steel was treated to some extent in the first part of this paper. A little may be added about the desirability of letting the ingot freeze after the onion or after the landlocking-type, and about the further treatment of the ingot. The slow cooling which produces the onion-type will tend to push the impurities towards the center, increasing also the segregation of phosphorus and carbon. H. M. Howe prefers freezing after the landlocking-type, casting the steel at low temperature in a cold mold. In that case the inclusions will be interlocked within the columnar structure and will be more evenly distributed. Thus the segregation will be less, but fewer particles will get time to rise and "slag off."

The columnar or landlocking structure will be deepest and most pronounced in the bottom part of the ingot because the mold is thickest there, and coldest when the pouring starts and it is found that the bottom end of the ingots gives more failures from flaky test-pieces than the top end. The author, for this reason, would prefer freezing after the onion-type, using hot molds or sand molds.

Columnar surface structure is weaker against strain in a tangential direction arising when the inner layers of the ingot pass the critical range. To prevent failure at this time it would be advisable to strip the ingot as soon as possible and put it in a soaking pit, thus equalizing the temperature before the outer layer has passed the critical. The depth of the columnar structure, which depends on the heat gradient in cooling, will probably influence the tendency to crack, and it will therefore be important to be able to calculate beforehand the temperature gradients for different sizes of ingots, molds and temperatures. Some trials in this direction have shown the author that the time-temperature curves for any point will be expressed by a series of exponential functions and probably too cumbersome to apply. Fletcher² has made approximate calculations for the same purpose, not considering, however, the heat conductivity.

The ingot should preferably be forged direct from the soaking pit. If it must be cooled down, it should be done in the pit or in ashes, while subsequent reheating must be done very carefully so that the inside does not crack or is left too cold for the subsequent works, which will then easily start interior cracks. With proper heating, forging is better done between V-dies than between flat dies, since the angle of flaw in the material then will change when the piece is turned and forged in the new position.

¹Journal, Iron and Steel Institute, 1907, p. 59.

²Engineering, 1918, p. 342.

The principal cause for flakes, which generally are found associated with low physical test values, was found to be nonmetallic inclusions. In making the steel, therefore, the greatest care should be taken to eliminate such inclusions as much as possible by a properly conducted boil which should die down without the addition of deoxidizers, when the steel is nearing the correct carbon content. When the oxygen present in the steel is reduced to the least practicable amount by the carbon (or added wash metal), and in good time before tapping, deoxidizers should be added only in sufficient quantity to prevent gas evolution ("rising") when the steel is poured—manganese and similar alloys of course in quantities wanted for physical properties.

Likewise much care should be taken that inclusions from other sources are not introduced, particularly when tapping and pouring.

It is theoretically and practically impossible to get a steel absolutely free from nonmetallic inclusions; the endeavor must be toward eliminating them as much as possible technically. Blowholes and strong local segregations should not be present in steel which is properly made.

The subsequent treatment of the steel in pouring, heating and forging is further of great importance, because cracking may start when strains set in from uneven heating or cooling, particularly dangerous at the period of critical contraction or expansion; or when strains are produced by improper forging.

Due to the fact that the inclusions present are most dangerous when the stress is applied at right angles to their largest section, it will be best to have as little reduction done as practicable so that the inclusions will retain the spherical form as nearly as possible when the forgings will be subjected to transverse stress.

Heat treatment can never eliminate inclusions and therefore never entirely prevent the formation of flakes; but a proper heat treatment which brings the steel surrounding the slag particles in the best condition to resist the propagation of cracks on straining the material will naturally improve the service qualities of such steel. Repeating the heat treatment and taking new test bars until good tests are found is unsafe for the same reason if flakes are once found in a steel. A bar taken from a nearby place may give a poor result, since the distribution of foreign particles or cracks is never even. It must be considered better practice to take tests from the forging before it is machined, and reject the piece entirely if fractures of test bars show flakes with nonmetallic inclusions when examined with the binocular microscope.

Carnegie Institute of Technology,
Pittsburgh, Pa.

Request for Quotation on Borax

Four thousand pounds of borax, of a grade suitable for use for the killing of flies, are required by the War Department. Prices on this material are desired f.o.b. place of storage or production and f.o.b. Camp Jackson, S. C. Bids will be received until 10 a.m., April 22, 1919, and must include: Discount for cash in ten days, delivery, description of containers and packing, approximate shipping cubage and weight, specifications that will be fulfilled by the material. Address reply to: Paints Branch of Raw Materials Division, Attention of Capt. A. O. Van Suetendael, Munitions Building, Washington, D. C.

Metal Strapping on Wooden Boxes

One of the quickest and cheapest methods of adding to the strength of a wooden box is to wrap it with thin, flat metal straps. The ability of a box to withstand the hazards of transportation may thus be increased several hundred per cent. Tests made at the Forest Products Laboratory for the War Department have provided some information as to how a box should be strapped to add most to its durability.

The best place to apply the strap is apparently about $\frac{1}{4}$ of the length of the box from the end. The strapping is preferably nailed at each edge of the box to hold it in place, having, of course, been drawn snug by special tools for that purpose. Nailing the strap in place works well on boxes made of lumber $\frac{1}{2}$ inch or more in thickness, but cannot be successfully used on thinner material because the nail splits the board. On thin boxes it is necessary to join the two ends of the strap (for which purpose there are several devices), thus making a metal band around the box held in place by tension.

Depending on tension alone to keep the strap in place is, however, open to one serious objection. Unless the box is constructed of dry lumber, shrinkage reduces its circumference to such an extent that the metal strap is no longer tight. This action not only reduces the effectiveness of the strap, but commonly permits it to slip over the end of the box. A shrinkage in moisture content of 10 per cent will permit the straps to fall off when the boxes are subjected to the ordinary hazards of transportation. A shrinkage of 5 per cent will loosen the straps considerably, but the shrinkage is rarely enough to permit them to fall off.

The effect of shrinkage of the box is also serious when the straps are nailed at any point, since it causes them to buckle or "festoon." The reinforcing effect of the straps is thus diminished and the box becomes dangerous to handle. It is important, therefore, that metal-strapped boxes which are to be in transit or storage for any length of time should be built of dry lumber.

Recovery of Waste Paraffined Paper

In the process of manufacturing paraffined paper and various products such as cartons, cups and wrappers, large quantities of impregnated paper stock are now wasted. In the making of paraffined paper alone, it is estimated, the daily waste amounts to 8 or 10 tons.

An opportunity for the recovery of a large part of such waste paper and impregnating material is offered in the application of a method recently developed at the Forest Products Laboratory, providing mill trials are as successful as the semi-commercial laboratory work indicates.

The recovery method consists in treating the finely shredded waste with petroleum oil solvent in a series of extractions, which removes practically all the paraffine. The paraffine is afterward separated from the solvent, which is used again. The solvent left clinging to the extracted paper is also recovered by a steaming process.

A paper fully as strong as the original can be made from the remaining pulp.

Bituminous Roofing Materials and Construction—II

Description of the Types of Bituminous Roofing: Built-up Felt Pitch, Rubber Roofing and Felt Base Shingles—Comparative Tests for Roofing Materials for Thickness, Tensile Strength, Absorption of Moisture, Pliability, Volatility and Fillers—Specifications

BY GEORGE LANDIS WILSON

SATURATED felts are used for what are known as "built-up" roofs; that is, roofs that are constructed or "built up" of the roof deck to fit the building. Such roofs when surfaced with gravel or crushed stone are popularly known under the generic term of "gravel roofs." The terms 5-ply, 4-ply and 3-ply refer to and correctly describe the number of layers of saturated felt which cover the entire roof area.

When gravel roofs are applied on a concrete roof deck the standard practice is to coat the concrete with pitch and apply a complete coating of pitch over each layer of felt; when applied over a wooden roof deck, the first coating of pitch is applied over the second layer of felt and a coating of pitch provided with each succeeding layer of felt.

Gravel roofs are not generally adapted for roof inclines exceeding 2 in. fall to the foot horizontal, and an incline of from $\frac{1}{4}$ to $\frac{1}{2}$ in. to the foot is better than an incline exceeding $\frac{1}{2}$ in., for the reason that it makes more practical the use of the maximum permissible amount of pitch and gravel on the surface, and as the "built-up" method using saturated felt and pitch provides a surface that is watertight or will hold water, instead of being capable of simply shedding water, there are many practical reasons in favor of the roof deck having a minimum incline.

PITCH COATINGS MUST BE UNIFORM AND COMPLETE

In "built-up" roofs the fundamental principle involved is that the coatings of pitch shall be uniform and complete, for the reason that a coating of pitch that covers only 90 or 95 per cent of a given area is of no value in preventing leaks in the other 10 per cent or 5 per cent of the area, and the roof covering would, practically speaking, be serviceable for just as long a time if such an incomplete coating were omitted altogether. On an average 25 lb. of pitch is required for coating each 100 sq.ft. between the felt layers; and 75 lb. is required for the surface coating into which the surfacing of gravel is embedded.

Felts saturated with coal tar, and pitch obtained by the distillation of coal tar, are the materials which have been most generally and widely used for constructing "built-up" roofs, and are the materials on which the reputation of gravel roofs has been established. There are almost numberless instances where such roofs have given watertight service for upward of 20 years without repairs, and many instances of a life of 30 and even 40 years. A limited amount of open-minded investigation will produce proof of these statements. What has been done can be done again. Tarred felt and coal-tar pitch, at least the equal in quality of materials pro-

duced in former years, are available and contractors capable of skillful handling of these materials are also available to any one who will pay the price. Other saturants and other pitches from various sources are sometimes substituted for or offered as superior in quality to coal-tar pitch for use in gravel roofs. None has thus far shown any special merit or proven the equal of the materials originally used.

The gravel surface has three important functions: It permits the use of 75 lb. of pitch to the square (100 sq.ft.) on the surface by preventing the pitch from flowing to the low points of the roof—if gravel were not used a paint coat of pitch is all that would be prac-

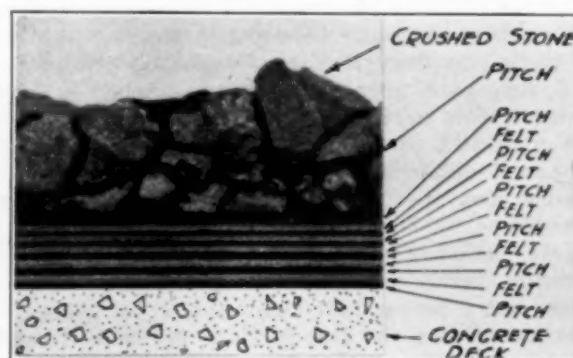


FIG. 1. GRAVEL ROOF APPLIED ON CONCRETE DECK. ILLUSTRATION ACTUAL SIZE

tical; it makes the roof fire-retardant (rated as Class "A" by the Underwriters' Laboratories); it protects the waterproofing material from wear and tear of the elements and more particularly from abuse, both necessary and unnecessary, to which most flat roofs are subjected. Crushed slag or any crushed rock may be used instead of gravel if it does not, like soft limestone, for example, disintegrate rapidly on exposure, or does not, as is the case with trap rock, crush into sharply angular particles. The standard practice is to require that the gravel or crushed stone be from $\frac{1}{4}$ to $\frac{1}{2}$ in. in size, and while slight variation from this range may be permissible, there are practical reasons for complying as nearly as possible with the standard.

PREPARED ROOFINGS

Prepared bituminous roofings are of two general classes: (a) those composed of a single layer of felt of various thicknesses; (b) those composed of two or more layers of felt or other fabric cemented together with bitumen. The multiple layer prepared roofings are designated as 2-ply, 3-ply, etc., by counting the layers of felt or fabric that are stuck together, what-

ever their thickness or whether they happen to contribute to the element of waterproofing or not. The single layer roofings can be subdivided into two general classes: "smooth surfaced," i.e., those on which the bituminous coating forms the wearing surface, and "mineral surfaced," i.e., those having granular material in the form of crushed slate, feldspar, etc., or natural gravel or pebbles forming the wearing surface. The "smooth surfaced" roofings are generally made in three weights standardized at 35, 45 and 55 lb., and through an unfortunate trade practice known as 1-ply, 2-ply and 3-ply, respectively. The industry is endeavoring to correct this misnomer and recently voted unanimously in favor of designating the three weights as, "light," "medium" and "heavy." The "smooth surfaced" variety is sometimes referred to as "skin-coat" roofing, because the saturated felt is coated with bitumen, while the multiple layer roofings do not generally have a coated surface. They are also known as "rubber" roofing, because they feel something like and have an appearance similar to rubber. The term "rubber" has been used to such an extent as to have practically become generic, as applying to roofing composed of a single layer of felt saturated with bitumen and coated with bitumen without a surface of granular material.

"RUBBER" ROOFING

The "rubber" roofings of each weight are produced in all sorts of qualities. Each manufacturer has his own ideas regarding the maximum to which he is willing to go in producing a serviceable article, whatever the cost. Likewise, each has his own idea about the minimum for which he is willing to stand sponsor in the effort to meet price competition. Most manufacturers produce four or more varieties under different trade names or brands, the price range between the maximum and minimum being roughly as 10 to 6. All "rubber" roofings have a finely ground soapstone or talc brushed over the surface to prevent sticking in the roll. This gives the roofing a light colored appearance when unrolled which is often retained for a considerable period. In order to provide a different appearance for the different qualities manufacturers use powdered soapstone of different degrees of fineness and sometimes a very fine sand, and also endeavor to control the size of the corrugations in the coated surface or pass the roofing through smoothing rolls after coating the surface, to remove the corrugations altogether. There is no standard practice in this endeavor to have the different grades of roofing distinctive in appearance, each manufacturer adopting whatever practice seems best suited to his particular line.

Mineral surfaced roofings are generally made on the same base as is used for 2-ply "rubber" roofing, and when a mineral surface is applied the other side of the felt is usually left uncoated. Crushed slate, either red or green, has during recent years become the most popular mineral surface. Apparently, crushed slate has some inherent merit that is not present in other forms of granular material, the most plausible reason advanced being that slate crushes into less angular particles than feldspar, quartz or other stone, and more completely covers the bitumen into which it is embedded. Another reason for the popularity of the slate surface is the color, and as this is natural in the slate it does

not fade. The standard weight of slate surfaced roofing is 80 to 85 lb. to the square.

Practically all prepared roofings are put up in rolls sufficient to cover 100 sq.ft. (known in the roofing trade as a square) allowing for whatever lap is recommended in the directions enclosed in the roll. A 2-in. lap is usually recommended, and in laying roofing with a 2-in. lap 108 sq.ft. of fabric is required to cover 100 sq.ft. of surface.

FELT BASE SHINGLES

The use of crushed red or green slate as a surfacing material for prepared roofing and the cutting of that roofing into shingles were the first development in the felt base roofing industry toward providing a roof covering having any artistic merit, the shingles in particular giving relief to the objectionable flat effect and conforming to the popular idea of what a roof surface should be like, inherited by reason of use for generations of wooden shingles and slate. The serviceability of the material used in a single layer has long been established, and the popularity of slate surfaced asphalt shingles has caused them to fill a long felt want in almost every community where roofing with artistic merit and at the same time fire retardant and of moderate cost was desired. They are dependable for use on practically every structure the roof surface of which has an incline in excess of 4 in. to the foot.

Slate surfaced shingles are generally furnished in size 8 x 12½ in. laid 4 in. to the weather, thereby providing triple protection; or in strip form, four shingles to the strip, 10 in. wide laid 4 in. to the weather and providing double protection.

Prepared roofing and shingles are sold under trade mark brands. Most manufacturers have been wise enough to maintain the quality in the several brands they have established. As is the case with cigars, new



FIG. 2. ENLARGED CROSS-SECTION "RUBBER" ROOFING



FIG. 3. ENLARGED CROSS-SECTION MINERAL SURFACED PREPARED ROOFING

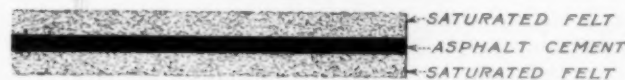


FIG. 4. ENLARGED CROSS-SECTION MULTIPLE LAYER PREPARED ROOFING

brands of prepared roofing are coming out all of the time to replace old brands which are run out, and for about the same reasons.

COMPARATIVE ROOFING MATERIAL TESTS

It is with some misgiving that the following tests are offered as a guide in buying roofing, but they are simple and, therefore, available to practically every buyer at a minimum of trouble and expense. It should, however, be kept in mind that there is no united opinion in the industry as to the value attached to any one of the tests; that there are no agreed maxima or minima, and that one piece of roofing might be distinctly sub-

standard when compared with another, if judged by one of the tests, and yet be a much better article.

Therefore, if one test is to be made use of in judging the comparative value of a piece of roofing, most of the other tests should also be made, for the reason that thickness may be obtained by use of inert mineral filler; tensile strength obtained at the expense of pliability; pliability by the use of soft saturant or coating readily volatile, etc. The tests are useful only as a basis for comparison. A succession of tests will show uniformity, or the lack of it. Uniformity is at least indicative of care in manufacturing processes.

Thickness: This is readily determined by the use of a micrometer registering thousandths of an inch and having a face at least a half inch in diameter. Mineral surfacings other than soapstone should be carefully scraped off before measurement is taken.

Tensile Strength: Specimens should be cut lengthwise from the middle of the sheet 5 x 1½ in. reduced to 1 in. wide for a distance of about 2 in. at the center. The ends of a specimen must be held in clamps which swing freely so as to avoid unfair tearing strain. Tests are usually made at a temperature of 77 deg. F. Ten breaking tests are averaged.

Absorption of Moistures: Tests should be started with pieces 18 in. square and due to freshly cut edges more readily absorbing water they should be trimmed 3 in. all around before re-weighing, making allowance for the reduced area when comparing weights. Immerse in soft water at 77 deg. F., for 100 hr., or suspend in atmosphere artificially saturated with moisture. Weight before and after tests indicates degree of thoroughness of saturation and waterproofing quality.

Pliability: Strips 1 in. wide cut lengthwise from center of sheet bent under water. Bend the sample around a series of cylinders ½, 1, 1½, 2 and 2½ cm. in diameter (approximately 1/16 to 1 in.) in exactly two seconds time. The absence or presence of cracks on the surface, or deeper cracks when bent over the smaller size cylinders, furnish the comparison.

Volatility: Tests at high temperatures are of little value. Exposure of samples hung edgewise to dry heat of maximum summer temperature, and careful comparison of weight before and after will disclose fugitive solvents and tendency to become brittle. If comparison of same samples before and after drying show marked increase in tensile strength it suggests lack of permanent waterproofing quality.

Inert Mineral Filler: Remove all mineral surfacing material, record the net weight of sample, burn it completely and weigh the ash. Dry felt contains from 6 to 10 per cent, by weight, of ash, and the dry felt weighs approximately one-fourth as much as the finished roofing without mineral surfacing. More than 3 per cent, by weight, of ash recovered on burning sample of roofing indicates use of inert mineral filler, either in dry felt, saturant or coating.

BUILDING SPECIFICATIONS

It is only fair to note that as a rule purchasing agents and architects make their drawings and specifications which relate to roof decks, roof faces, joinings, flashings and connections so incomplete, indefinite or general that the owner is dependent almost entirely upon the skill and good faith of the roofing contractor and his employees for serviceable roof protection. When an effort is made to draw a drum-tight specification

the result is frequently an unworkable instruction. In the absence of competent and complete inspection a rigid specification serves only to eliminate the conscientious bidder and insure the presence on the job of adventurers, willing to take any chances.

In the purchase of roofing this condition of indefiniteness, when recognized at all, is offset by the guarantee. The guarantee is a form of abuse which has survived longer than 50 years from the early days of the industry when bitumen roofs were experiments offered to replace unsatisfactory metal roofs. No guarantee ever yet kept water out of a building. At its very best the guarantee merely secures repairs, after the roof has leaked, without direct charge. It never covers consequential damages to the interior of the building or its contents. The existence of the guarantee never serves to deter the irresponsible adventurers from taking chances. On the other hand, it frequently serves him as self-justification for producing a roof calculated to a nicety to just "get by." The architect or engineer who permits this does not serve his client faithfully.

It is impossible to cover fully within the limits of an article like this all of the problems which grow out of the endless combinations that may be produced from this assortment of bitumens, gums, solvents, thinners, fibers, fillers, weight-makers and adulterants. The mere mention of some of them causes the observer of ordinary intelligence accurately to visualize their probable value for roofing purposes, or the lack of utility which they represent in the hands of any so ignorant or unscrupulous as to use some of them. Aside from labor, fuel, equipment and plant supplies, probably 90 per cent of the industry represents the utilization of what is, or until within recent years was, commercial or domestic waste materials. This fact has been unfairly made the excuse for turning out roofing materials which are deficient in tensile strength, ductility, durability and weatherproofing qualities. Those are the requirements which measure the utility of roofing faces in terms of service to the ultimate consumer. Success in this business is in direct proportion to the delivery of such service.

GENERAL CONCLUSIONS

Other things being equal, bituminous roofs are serviceable in direct proportion to the quantity of bitumen uniformly contained in each square foot of the covering.

Felt, and mineral surface if used, must be ample in quantity to permanently hold waterproofing material.

Joinings, flashings and connections require for their construction real skill, based upon experience, otherwise they surely cause trouble, however good the roofing material may be.

In general coal tar pitch makes the most satisfactory flat roofs, while asphalt from various sources is more readily adaptable for steep roofs, but each must be properly combined with suitable felts.

Flat roofs should be flat, the more nearly level and providing some drainage the better; while steep roofs should be steep, not less than 4 in. fall to the foot. A fall of 5 to 6 in. to the foot is best in latitudes where there is ice and snow.

Roofing of relatively temporary nature is justifiable only on buildings known to be temporary, but during that predetermined temporary period it must be quite as tight as any other roof.

Recent Chemical and Metallurgical Patents

Canadian Patents

Extracting Iodine and Other Chemical Products From Seaweed by Dry Distillation.—Iodine or like products are extracted from seaweed by dry distillation in a closed retort. The gases are passed through a condenser and the uncondensed gases are passed through a metal salt which will absorb the volatile iodine and bromine. The residue of the retort is soaked with water and the dissolved salts are separated. (Canadian Patent No. 187,721, J. A. W. BREDENBERG.)

Refining of Volatile Metals.—The metal to be refined is fed in an electric-arc furnace through a liquid trap formed by said metal, so as to maintain a metal bath in the furnace bottom, the surface of the bath is exposed to heat from the arc and the metal vapors are removed and condensed. (Canadian Patent No. 187,864, S. HULDT.)

Alumina Purification.—The impure alumina resulting from the calcining of alunite and the leaching of the calcine is mixed in a finely divided condition with water to form a pulp, and the resulting pulp is subjected to a flotation operation with the addition of an agent promoting the flotation of the alumina, and thereby separating the alumina in the form of a froth from the impurities and recovering the alumina from the froth. (Canadian Patent No. 188,441, J. W. HORNSEY, assigned to the Minerals Products Corp. of New York, Jan. 28, 1919.)

White Gold, a Substitute for Platinum.—The process of manufacturing white gold consists of fusing fine gold, pure nickel and pure zinc and mixing them thoroughly while in fusion. The proportions of the components are: Gold 75 to 85 per cent, nickel 10 to 18 per cent, and zinc 2 to 9 per cent. (DAVIS BELAIS, Canadian Patent No. 188,628.)

English Patents

Distilling Zinc.—To obtain the maximum amount of zinc in zinc distilling processes, the zinc dust deposited in the condenser is subjected to a rubbing action and to compression by means of a screw mounted to rotate in the bottom of a condenser. The zinc dust is forced by the screw to the condenser outlet and into a receptacle of molten zinc. The amount of compression and the duration of the pressure may be adjusted by varying the pitch of the screw and the extent to which the screw enters the opening. (English Patent No. 120,549—1918. E. S. BERGLUND. Not yet accepted. Jan. 8, 1919.)

Production of Ammonium Sulphate and Alumina.—Clay, bauxite and other natural substance containing aluminium with iron and silica acid is treated with sulphuric acid to yield an impure solution of aluminium sulphate. The solution is treated with a reducing agent such as sulphurous acid or a sulphite to reduce ferric to ferrous sulphate, and is mixed while at 70 to 100 deg. C. with ammonium sulphate, allowed to settle at this temperature, and the decanted solution is cooled to separate crystals of ammonium

alum. The crystals are decomposed by exposing them to ammonia, either gaseous or in solution, to yield ammonium sulphate and aluminium hydroxide, which may be heated to obtain alumina. (English Patent No. 120,550—1918. J. P. A. LARSON and W. D. BERGMAN, both of Stockholm, Sweden. Not yet accepted. Jan. 8, 1919.)

Platinized Asbestos as a Catalytic Agent.—Platinized asbestos for use as a catalyst is prepared by dissolving platinum in aqua regia, evaporating the solution to dryness, extracting the residue with hydrochloric acid, neutralizing the solution with soda, mixing it with a paste of asbestos and distilled water, and reducing at 60 deg. C. by formic acid. The product is finally washed, dried, carded and made into flakes. (English Patent No. 120,551—1918. E. FRABETTI, Rome, Italy. Not yet accepted. Jan. 8, 1919.)

Thorium Compounds.—Solutions containing thorium obtained, for instance, by dissolving in water the product of the action of sulphuric acid or monazite sand are treated with oxidizing agents such as potassium or sodium permanganate or hydrogen peroxide in the presence of acid. Hydrated thorium oxide or peroxide is precipitated and may be dissolved directly in nitric acid or other acid, and the resulting solution may be crystallized. The thorium nitrate may be purified by precipitation by the oxidizing agent first employed, or the solution may be treated with sodium carbonate in excess, which dissolves the thorium carbonate first produced. The solution is filtered and treated with caustic soda to precipitate thorium hydroxide, which is then dissolved in nitric acid. (J. V. and W. A. CLARKE, London, England. English Patent No. 120,748—1918. Jan. 15, 1919.)

Malleableizing Cast Iron.—Iron castings to be malleableized are heated in the presence of Mond blast-furnace, or like gas, containing carbon dioxide and hydrogen. Sufficient carbon monoxide is preferably present to prevent excessive decomposition of the carbon dioxide by the hydrogen. Sulphur and hydrocarbons are preferably removed from the gas before use. The temperature of treatment is 700 to 800 deg. C. for black-heart castings, and 800 to 950 deg. C. for white-heart castings. (English Patent No. 21,074—1918. F. PERRY and INDUSTRIAL INVENTIONS, LTD., Tipton Staffordshire, Eng., Jan. 29, 1919.)

Lead Arsenate.—Lead arsenate is produced by thoroughly mixing, preferably by rubbing or grinding, lead carbonate or white lead with arsenic acid in the presence of water. A concentrated solution of arsenic acid may be used, and water may be added at the end of the reaction to produce a paste of the desired consistency. (English Patent No. 121,101—1918. J. LYTLE, Dunbyon, Formby, Eng., Jan. 29, 1919.)

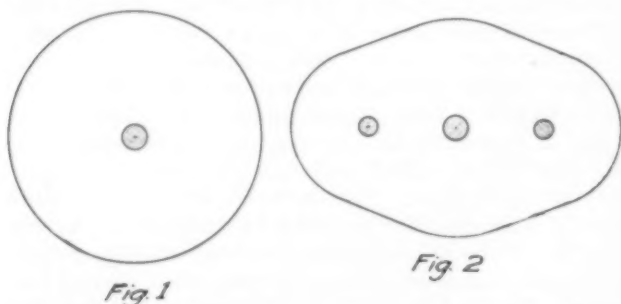
Preservative Coating of Metal Surface.—A preservative coating is formed on metallic articles by dipping the article into an oil, for example, a mixture of whale oil and mineral oil, draining and then heating to a temperature high enough to gasify the volatile constituents in an oven, which permits the escape of the lighter gases. A suitable oven is one having an outlet at the top, the aperture of which can be varied, and a suitable temperature is about 300 deg. C. (English Patent No. 121,150—1918. N. C. F. JENSEN, Southall, Middlesex, Eng., Jan. 29, 1919.)

Vom Baur Electric Furnace

BY C. H. VOM BAUR

VERY soon after electric furnaces in the iron and steel industry were placed in commercial operation in the United States, some eleven years ago, it became evident that one of the limits of their possibilities depended on the life of the refractories. All kinds and types of electric furnaces have to take care of this item much more than any open-hearth furnace. The experience of many electric furnace operators and designers has been along these lines. The simplest refractories of any arc furnace are those of the single phase, single electrode type, with a bottom electrode, when this has a round hearth and the carbon electrode at its center. (See Fig. 1).

It is evident that the heat at the inner contour of the side walls and of the slag line of this furnace is the same at any point thereof. Consequently when the side walls



burn away they do so equally. That is to say, there are no hot spots on any portion of the side walls or slag line, due to the heat of the arc, and manifestly no portions of the refractories need repairs when properly laid, prior to some other portion. As the single phase furnace of any but the smallest sizes is not popular with central station managers, it is seldom seen today in the newer installations, polyphase furnaces having almost exclusively taken their place.

At first, on account of the many advantages of the polyphase furnace, compared to the single phase, the refractory feature as above mentioned did not receive the attention it deserved until the appearance of the Vom Baur electric furnace, which has with its three electrodes, 3-phase 2-wire, the same good heat distribution as the simple single-phase furnace, as shown in Fig. 1. This good heat distribution in this furnace is accomplished by the combination of placing three electrodes in a straight line, and very nearly knowing the electrical heat, at least close enough for all practical purposes, which emanates from any of these electrodes after the bath is in the molten state, or nearly so. The contour of the inner refractories can easily be ascertained so as to give a curve to the refrac-

tories which is correct, so that the heat at the slag line, at the side walls and at the hearth banks is the same, thus assuring among others the equal burning away of all the refractories involved. Only very small allowances from the theoretical have to be made in order to accomplish this purpose. The shape as given to these furnaces is shown in Fig. 2.

Fig. 2 shows a well defined minor axis drawn through the middle electrode, and this shape is the natural result of the radiated heat reaching points on the minor axis from the three electrodes. Theoretically, the center electrode would have 41 per cent more heat than either of the end electrodes, but it is not possible to reach this condition practically and maintain the arcs at their best setting. The current at the central electrode is therefore diminished by several per cent and the extreme points in Fig. 2 are brought slightly together. Even so, the heat from the central arc is fully one-third more on an average than from either of the end arcs, and consequently in order to keep the refractories at their proper distances the metal bath has a larger surface than the furnace would have if each of the electrodes ever gave off an equal amount of heat. With basic operation the advantage is that the metal presents a greater slag area for the same tonnage. As the rate of refining depends not only on the chemical composition of the slag and the heat at the point of contact between the metal and the slag, but also on the amount of surface engaged between the slag and the metal, it follows that the rate of refining is quicker.

There is very little poking to be done when melting down cold scrap, as there are no hot or cold spots on the side walls or near the doors. The quick melting down with this furnace, as with all others, depends mostly on the amount of transformer capacity which the furnace has. However, as this furnace has an even heat distribution at the side wall refractories, it is more efficient than the other furnaces which lack this feature.

Special attention has been given to the doors, which have watercooled frames, fit very snugly, yet allowing

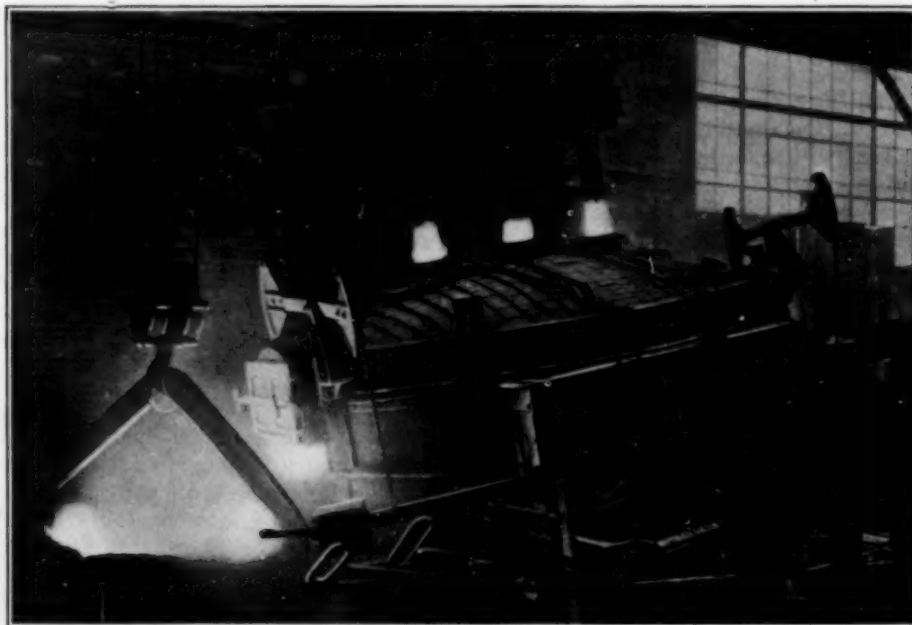


FIG. 3. DISCHARGE OF 6-TON FURNACE AT THE HERCULES STEEL CASTING CO. PLANT

for all expansion, and can be tightened after they are closed by giving two handles a few turns.

Structurally, the furnace is very strong, having a rounded and cone-shaped bottom connected with the upper shell, which is a series of curves. This sets on two rocker arms and the whole is tilted by means of connecting rods from suitable geared mechanism in such a way that when the furnace has reached its maximum tilting position, if the operating motor should continue to run for any reason, the furnace goes back to its normal position nevertheless. The tilting mechanism also allows the furnace to tilt slightly backward some 6 deg. and 7 deg., so that the slag can be taken off this door instead of from the spout. Both doors are used for charging.

The center of gravity of the furnace is low, as the heavy parts of the standards are no higher than is needed for the full travel of the arm holding the electrodes, and as these have an upward tilt the upright standards are still further shortened. For carrying the copper cables a much lighter structure is used, all of which can be seen from the photographic reproductions.

Either carbon or graphite electrodes can be used and changed quickly; either hand or automatic electrode control is furnished. The oval shape and turtle-back construction of the roof makes a very strong construction, standard brick being used throughout for the roof construction, excepting a few special electrode brick. The electrical connections are the simplest possible, being merely three sets of cables from the transformers to the electrodes, and no complication on the high tension side. Electrically the furnace conditions are satisfactory to the central station managers, the power factor being around 90 per cent and the phases not being distorted more than with other arc furnaces. After continued operation it has been observed that the furnace does not bulge at all, this being another indication of the even heat distribution as mentioned.

The furnace is equally well adapted for melting down miscellaneous steel scrap for castings on either acid or basic bottom, selected scrap for quality and tool steels, or for melting down cast iron borings, or the like, or for use with malleable iron. The furnace is made in sizes from $\frac{1}{4}$ ton up to 30-ton sizes and for any electrical condition. The first of these furnaces in this country of 6-ton size has been placed in operation at the works of the Hercules Steel Casting Co., Milwaukee, Wis. Others are being installed both here and abroad, and the patents for France, Belgium, Italy, Switzerland, and Spain have been disposed of to Le Flaive & Co. of St. Etienne, France.

Woolworth Bldg.,
New York, N. Y.

Personal

MR. OLIVER U. BRADLEY is U. S. oil and gas inspector for the Department of the Interior at Muskogee, Okla., with offices in the Federal Building.

MR. W. J. COTTON, formerly chemical examiner for the United States Civil Service Commission, has joined the staff of the Color Investigation Laboratory of the Bureau of Chemistry, Washington, D. C.

MR. COURTENAY DEKALB recently sailed for Spain to investigate the metallurgical and mining resources of that country for the Department of Commerce.

MR. J. H. DEPFELER of the Metal & Thermit Corp. has been elected a director of the American Welding Society.

MR. HENRY B. FABER, head of the school of pyrotechnics, Columbia University, was recently tendered a dinner and presented with a loving cup by the staff of the school. Mr. Faber has also been appointed associate in the department of chemical engineering at Columbia University.

LIEUT. RUSSEL C. GEBERT, recently released from the Ordnance Department of the Army, has been made chief metallurgist and superintendent of heat-treating at the Hammond Steel Co., Syracuse, N. Y.

DR. FEDERICO GIOLITTI is to be awarded the Bessemer medal of 1919 by the Iron and Steel Institute of Great Britain at its meeting on May 8.

MR. SAMUEL M. GREEN, president of the Samuel M. Green Co., Inc., Springfield, Mass., has become a director of the Norwalk Iron Works, South Norwalk, Conn.

PROF. H. E. T. HAULTAIN of the mining department of the University of Toronto is in charge of the Vocational Training Branch of the Department of Soldiers' Civil Re-establishment under Mr. W. E. Segsworth, a mining engineer of Toronto, who is in charge.

CAPT. C. A. JENNINGS has received his discharge from the Construction Division, Utilities Branch, of the Army, and has returned to the technical staff of Wallace & Tiernan Co., Inc., to resume charge of the Chicago office. Captain Jennings' work in the Army covered the supervision, operation and maintenance of water purification and sewage treatment plants in various camps.

MR. W. A. MAXWELL, formerly superintendent of the open-hearth department of the Homestead Works, Carnegie Steel Co., has resigned to become assistant general superintendent of the Cambria Steel Co., Johnstown, Pa.

DR. WILLIAM C. MOORE, for the past five and a half years research chemist for the Cleveland plant of the National Carbon Co., Inc., has resigned in order to take charge of the physical chemical research in the department of immunology in the school of public health and hygiene recently established by the Rockefeller Foundation at Johns Hopkins University, Baltimore, Md.

PROF. ALBERT SAUVEUR of Harvard University has returned to Cambridge, Mass., from France, where he had charge of the section of metallurgy in the technical division of the United States air service.

MR. C. C. WALLACE, formerly manager of loading of munitions section of the Stenotype Co., Indianapolis, Ind., is now director of development and service of the Powdered Coal Engineering & Equipment Co. of Chicago.

CAPT. A. U. WETHERBEE, who recently received his discharge from the Chemical Warfare Branch of the service and who was formerly chief engineer and assistant works manager of the Niagara Alkali Co., has accepted a position as chief engineer with the Powdered Coal Engineering & Equipment Co. of Chicago.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, April 26.—The non-ferrous market has hitherto been uncertain but is expected to follow the conditions created by the iron and steel activity due to lowered prices.

Aluminium:—Conditions are unusually quiet, as aluminium has not declined. Ingots 98-99 per cent, 29-31c. lb. Sheets 18 gage and heavier, 42c. Powder, 0.70-1.40 lb.

Copper:—The market remains quiet with prices standing at 15 $\frac{1}{2}$ to 15 $\frac{3}{4}$ c.

Copper sheets, hot-rolled.....	lb.	\$0.22	.....
Copper sheets, cold rolled.....	lb.	.23	.....
Copper bottoms.....	lb.	.30	.....
Copper rods.....	lb.	.19	.....
Copper wire.....	lb.	.17	\$0.18
High brass wire and sheets.....	lb.	.18	.....
High brass rods.....	lb.	.17	.....
Low brass wire and sheets.....	lb.	.18	.....
Low brass rods.....	lb.	.21	.....
Brass tubing.....	lb.	.29	.....
Brass tubing.....	lb.	.33	.....
Seamless copper tubing.....	lb.	.28	.....
Seamless bronze tubing.....	lb.	.29	.....
Seamless brass tubing.....	lb.	.30	.....
Bronze (gold) powder.....	lb.	1.00	.....

Antimony:—Wholesale lots are offered from 6½ @ 7c. and jobbing at 7½c. The market has a brighter outlook.

Lead:—Prices have declined to 4.75c. per lb. in East St. Louis and 4.975c. per lb. in New York. Sheet lead, 7½ @ 8c. per lb.

Tin:—The 72½ price fixed by the committee continues and buyers are reluctant, knowing that a considerable decline will come eventually.

Zinc:—Future quotations at East St. Louis are rising: May, \$122.50; June, \$123.50; July, \$124.50; August, \$125, and September, \$126 per ton. New York spot is \$121.50. Zinc dust, 14c.; sheet zinc, 11c. per lb.

OTHER METALS

Bismuth.....	lb.	\$3.20 —	\$3.65
Cadmium.....	lb.	1.40 —	—
Cobalt.....	lb.	2.50 —	3.50
Magnesium.....	lb.	1.75 —	2.10
Mercury.....	75 lb.	75.00 —	—
Nickel.....	lb.	.40 —	.45
Tungsten.....	lb.	Nominal	—
Iridium.....	oz.	175.00 —	—
Palladium.....	oz.	115.00 —	120.00
Platinum.....	oz.	99.00 —	100.00
Silver.....	oz.	1.01 —	—

The Iron and Steel Market

By the middle of April it became generally recognized that the Industrial Board plan for handling the steel market had failed. The popular version was, of course, that the plan failed because the Railroad Administration refused to "co-operate." Scarcely any thought was given to a similar refusal on the part of the Navy Department. Sentiment was not lacking. The Railroad Administration is unpopular, while the Navy Department is an institution of which Americans are proud.

The steel trade was quick to accept as final the apparent failure of the Industrial Board to secure the results it had expected. The steel industry did not seek the Industrial Board for the purpose of suggesting that if a few dollars a ton stood in the way of Railroad Administration endorsement of the plan the barrier might perhaps be removed. For this ready adoption of the idea that the plan had failed there was another reason, which from its nature is not dilated upon, and that is the absolute refusal of the Department of Justice to endorse the plan. The department would not give approval, in advance, of a plan announced to operate for the remainder of the year when there was a possibility that matters might so shape themselves that it would in essence represent an agreement for the maintenance of prices. It was that feature of the whole arrangement that had appealed to the steel industry in the first place. Orders for a few hundred thousand tons of rails, with perhaps a few tens of thousands of freight cars and a few thousand locomotives, represented merely a detail. The important feature promised was that the sellers of steel could assure the public that there was no occasion to wait, that no lower prices could be expected at any time this year. Even at best, however, there was a weak spot in the argument, for the investor in a construction job would not weigh merely the respective advantages of building now or six months hence, but also the advantages respectively of building this year or next year, or even the year after.

The steel trade was as quick to assert that the Industrial Board plan was a failure and that an open market for steel products would follow as it was slow in taking any steps to establish an open market. That steel prices would eventually decline from the level established March 21 has been generally predicted or admitted, but the time of the decline has been altogether in doubt. The break may occur any day, or may be delayed until next June, possibly even longer.

STEEL ORGANIZATION APPEARS INTACT

The organization of the steel trade appears to remain intact, this organization consisting merely in a mutual understanding that what is good for one is good for all and what is good for all is good for one. On account, however, of the very unequal distribution of old orders, upon which, rather than upon fresh bookings, the steel mills are chiefly operating, some producers may easily conclude that their

best course lies in cutting prices even though a market decline would be disadvantageous to others. In the price maintenance operation of 1908 the circumstances were altogether different, as it was then contrived that all producers should operate at substantially the same rate. At the present time operating rates are widely divergent.

The philosophy of the steel trade is that inasmuch as light operation involves heavy overhead and therefore relatively high cost, prices should be maintained as well as the thing can be done, until it is reasonably certain that reducing prices will fill the mills, giving a lower production cost and at the same time enabling the market to start upon an advance. No matter what the price level may be, when mills begin to fall behind in deliveries advances begin. Given such a condition, it matters relatively little to what level prices may temporarily fall, as they can quickly recover, but if prices fall without full operation being produced the tendency is for them to decline farther. For instance, a mill operating at 65 per cent can well afford to take additional business at particularly low prices in order to raise the operating rate to 85 per cent, as the cost of production of the entire output will be reduced. Steel prices, therefore, will decline when producers feel there is large business to be secured. Thus far they have not displayed a hopeful frame of mind.

Steel mill operations, which averaged 87 per cent of capacity in January and 77 per cent in March, declined to a rate of not over about 60 per cent in the closing days of April. Even that is not an altogether bad rate, if maintained uniformly throughout the industry, but some small plants were closed entirely while some large independents operated at not over 45 per cent. Most of the Steel Corporation subsidiaries operated at 70 per cent or more, the Steel Corporation having apparently picked its orders, long ago, in anticipation of some such situation as this.

PIG IRON INDEPENDENT OF STEEL, MARKETWISE

Marketwise, pig iron has shown its entire independence of steel. The merchant furnaces gave but lukewarm assent to the Industrial Board plan when first proposed, and when the Industrial Board prices were announced March 21 they expressed their disapproval of the price structure very plainly, as they felt that steel was reduced altogether too little in proportion to pig iron. The pig-iron market had been an open one until the Government took charge as a war-time measure, and the furnaces had no objection to a return to that condition. Accordingly they stated to all interested that there would be an open market in pig iron. It was not that the furnaces desired prices to decline, but that they desired, through actual experiment, to ascertain where prices would go if left to themselves. The individual furnace could then determine whether or not to blow out, awaiting either higher prices or lower production cost or both. The experiment, however, has been rather unsatisfactory thus far, the reaction being very sluggish. In other words, while merchant furnaces are willing to cut prices few opportunities, by way of inquiries of any size developing, have been afforded, and in most districts the March 21 prices still obtain, nominally at least.

The Chemical Market

New York, April 25.

COAL-TAR PRODUCTS:—Considerable improvement is noted in this situation, particularly in the way of heavy crudes. A number of the items have been in demand in a liberal way for the past month or more, and it is not exaggerating to state that more material has been sold during the past month or six weeks than for six months previous to this time. Benzol in particular has felt the effects of the increased demand. As a result prices have advanced from 10 to 15 per cent during the past two months. It is also encouraging to producers to note that buyers are contracting over longer periods, as well as buying in large quantities. The other crudes are also more active and prices in most cases have advanced. Naphthalene, however, is an exception; although material is moving much more freely, prices are easy.

Phenol:—The demand has improved and large quantities

are moving. While prices are slightly firmer and higher, they are not greatly changed. This is due to the fact that large quantities are available.

Benzol:—A decided improvement is noted. Buyers are closing for large quantities both spot and contract. During the past week prospective buyers have experienced difficulty in securing spot material, which is so unusual that it is a matter of discussion in the trade.

Naphthalene:—Buyers are closing for large quantities. Although the demand is hardly as brisk as it was when the industry was booming, there is some improvement. The fact that large quantities of material are available tends to keep prices at low levels.

Toluol:—The volume of business closed is quite heavy in the aggregate, but the demand is mostly for moderate quantities. Tank car lots are not moving to any extent, but nevertheless prices are stiffer.

Aniline Oil:—While there appeared to be a firmer undertone to this market for a time, prices were lowered in most instances by second hands shading producers' prices.

Benzaldehyde:—The production is heavier than formerly, with the demand only fair, and prices are easier as a result.

Paramidophenol:—The production has increased of late, but the demand is quite regular and prices are unchanged.

Orthotoluidine:—Buyers are operating on a conservative basis, the production has increased, and prices while quotably unchanged are shadable in most instances.

H Acid:—Most of the business passing is for small quantities, material is plentiful and prices are lower.

Phthalic Anhydride:—There are some large factors competing in this situation and prices have been slashed in some instances in an endeavor to line up business.

Xylol:—The demand is only routine and prices, while quotably unchanged, are little less than nominal under the circumstances.

Paratoluidine:—Consumers are limiting their purchases to small quantities, with prices somewhat lower.

HEAVY CHEMICALS:—While there has been no resumption of important activities in the heavy chemical market, the past few weeks have shown more interest from buyers and producers are expecting a resumption of activities in the near future. A better inquiry for export material was noted which resulted in some improvement in trading in general in this direction and handlers of this business state the outlook for an increasing business is promising. The large tonnage used by the Government for the shipping of food supplies is easing up from week to week and the matter of space is in consequence more encouraging. Local trading is still confined to small-lot transactions, but consumers' stocks of many of the items seem to have become depleted and a slight improvement on the whole is noted.

Soda Ash:—Although there has been nothing in the way of any important trading reported, that is for material over the balance of the year, consumers appear more frequently in the market but are still confining their purchasing to immediate needs; however, this activity seems sufficient to keep the market for bag material firm. Bags from the warehouse were offered by second hands at from \$1.55 to \$1.60 while barrels were available at \$1.70 to \$1.75. No movement was noted in any direction, for double bags which were held at 2c. Middle West, with prices on a parity on the Pacific coast.

Caustic Soda:—The market for this material continues in a very weak position with the resale operators in control of the situation. An effort on the part of manufacturers to meet this condition has resulted in price declines among second hands and offerings were made as low as \$2.50 ex-store, with other directions holding at \$2.60 to \$2.65. Manufacturers toward the latter part of the week were quoting \$2.80 f.a.s. and intimated on a firm bid this price might be shaded.

Bleaching Powder:—Trading, for the most part, is direct, but the lack of demand has again had its effect on the market with manufacturers offering large export drums at 2c. f.a.s., while domestic drums were quoted at \$1.40 to \$1.50 works.

Chlorate of Potash:—There has been a fairly steady business passing for this commodity for export purposes, but the present rate of absorbing material is having no

effect on stocks; however, trading is of sufficient volume to take the slack off the market. Prices for the domestic product are firmly maintained at 35c. to 36c. while the Japanese variety is offered at 29c. and 30c.

Sodium Sulphide:—A better demand was noted during the past week for this material and several important sales were reported which resulted in a firming up of the situation. The 60-62 fusel is now held in most instances at 4½c. with the 30-32 crystals being quoted at \$1.90 to \$2.

Sodium Formate:—Comparatively little is heard of this item in the general market; however, producers report a steady business passing, particularly for the crude material, which is subject to a fair demand. This item is held at from 25c. to 28c. according to quantity, with the crystals held at 35c., although some business has been closed below this figure.

Calcium Carbide:—No new developments have set in to indicate any firming up in this market, with sales noted at below 5c. However 5½c. to 5¾c. is generally asked for material crated for export.

Bichromate of Soda:—The lack of demand is having its effect in this market, with prices steadily declining for resale material. Manufacturers, however, are striving to hold the market at a level of about 10c. ex-store, but resale offerings were made at from 9c. to 9½c.

Bichromate of Potash:—While there has been no resumption of any important activities for this material, there seems to be sufficient business passing to keep the spot situation well sold up. Prices are quotably unchanged at from 34c. to 35c. f.a.s.

Cream of Tartar:—While the item has been neglected for quite a period, a fair volume of export trading has developed during the past week, which resulted in an advance in prices, from 55c. to 75c., with some now holding as high as 59c.

Potash Chrome Alum:—Available supplies of this product are only in limited quantities and in scattered lots. Spot material is generally held at from 19c. to 20c., while that for shipment about the middle of May is held at 18½c.

Chicago, April 25.

Conditions in the chemical market in Chicago continue very unsatisfactory in that quotations on the entire line of heavy chemicals and coal tar products mean very little. Large stocks on hand and a production in excess of sales have produced a condition whereby a buyer with cash can make purchases below the market and in many cases below actual cost of production. An example is caustic soda, on which the mill cost is \$2.50 and market quotation \$3.25. Cash buyers would have no difficulty in securing carload lots at \$2.40. Carbolic acid can be had by merely paying for the container. These items are, of course, of exceptional weakness.

Consistently falling markets of the past few weeks have confirmed regular consumers in hand-to-mouth habits. Concerns normally anticipating in their purchases thirty days are now content to secure a week's supply, saying that the less they buy the more money they save, as next week they are sure to get lower prices.

Indications are, however, that this condition is nearing an end. Mercury has recently advanced and vegetable oils all show a tendency to be firmer in price; some items of this line are actually up ¼ to ½c. Soya bean oil, particularly, is in good demand. The announced policy of the Government to dispose of additional chemical stores in such manner as to least disturb the market is having a good effect.

FLOTATION OILS.—Prices are firm and sales very satisfactory. The annual spring clean-up, which was almost neglected last year on account of the war, has tended to strengthen the turpentine market, all other items in the line being affected to a certain degree.

NAVAL STORES.—Naval stores have been rather uncertain for some time, but with a gradual let-up of labor shortage in the producing fields and a continuance of consumption, conditions are very satisfactory. Sales for April are ranging 60 per cent in excess of those for last month. The market can be said to have certain indications of a downward tendency, or rather of an "evening up" tendency, with no great reductions to be expected.

Imports and Exports

The Department of Commerce reports the following imports and exports for February, 1919:

IMPORTS (TOTALS) AND EXPORTS (BY COUNTRIES) OF GLYCERINE

Imports			Exports		
	Lb.	Value		Lb.	Value
	10,936	\$4,657			
Countries	Lb.	Value	Countries	Lb.	Value
Norway.....	112,000	\$20,160	Argentina.....	212	\$119
Portugal.....	30	35	Bolivia.....	215	62
England.....	182	92	Brazil.....	2,250	1,472
Bermuda.....	200	59	Chile.....	12,492	6,739
Canada.....	1,290	315	Colombia.....	1,579	822
Costa Rica.....	150	32	Ecuador.....	1,400	334
Guatemala.....	1,566	807	British Guiana.....	350	220
Honduras.....	32	13	Peru.....	4,856	3,035
Nicaragua.....	557	297	Uruguay.....	50	30
Panama.....	209	54	Venezuela.....	1,235	639
Salvador.....	29	15	China.....	17,975	4,707
Mexico.....	7,737	2,725	British India.....	13,200	4,600
Newfoundland.....	25	15	Straits Settlements.....	6,750	4,151
Trinidad.....	490	152	Hongkong.....	14,500	4,930
Cuba.....	24,256	8,414	Japan.....	109,105	37,821
Dutch West Indies.....	50	27	Philippine Islands.....	50	16
French West Indies.....	50	30			
Dominican Republic.....	45	45	Total.....	335,137	\$102,984

EXPORTS OF CAUSTIC SODA AND SODA ASH, BY COUNTRIES

Caustic Soda			Soda Ash		
	Lb.	Value		Lb.	Value
Countries	Lb.	Value	Countries	Lb.	Value
Denmark.....	100,320	\$7,000	1,807,639	\$45,910	
Greece.....	80,500	3,220			
Norway.....	156,860	7,456			
Serbia.....	22,400	1,100			
Spain.....	2	2			
Sweden.....	165,640	8,428	1,402,760	49,157	
British Honduras.....			20	1	
Canada.....	742,048	34,805	1,390,497	27,848	
Costa Rica.....	9,120	547	300	14	
Guatemala.....	735	42	3,500	140	
Honduras.....	17,040	758	1,296	89	
Nicaragua.....	31,359	1,644	1,500	49	
Panama.....	8,100	413	5,600	168	
Salvador.....	2,532	137	500	20	
Mexico.....	976,290	49,225	721,925	20,127	
Newfoundland.....	50	5			
Barbados.....	23,200	1,384			
Trinidad.....	1,500	90			
Cuba.....	252,117	8,496	430,177	6,264	
Dutch West Indies.....			2,000	62	
Dom. Republic.....	25,600	1,266	12,000	430	
Argentina.....	1,060,601	65,010			
Bolivia.....	22,400	1,000	2,800	110	
Brazil.....	1,589,309	107,841	1,265,263	52,858	
Chile.....	144,023	8,189			
Colombia.....	102,096	8,624	33,419	1,335	
Ecuador.....	4,620	207			
Peru.....	509,624	22,772	86,100	3,675	
Uruguay.....	638,300	31,704	56,000	744	
Venezuela.....	38,605	1,891	3,000	90	
China.....	4,114,100	209,479	261,212	8,772	
British India.....	502,265	22,801			
Straits Settlements.....	60,200	3,141	1,200	36	
Dutch East Indies.....	1,200	66	44,000	1,800	
Hongkong.....	489,006	23,452			
Japan.....	910,983	47,665	3,764,070	148,294	
Siam.....	41,100	2,445			
Australia.....	373,442	22,594	330,312	16,215	
New Zealand.....	539,010	33,025	1,960	98	
Other British Oceania.....	3,650	310			
Philippine Islands.....	659,475	27,137			
British West Africa.....	56	3			
Total.....	14,422,675	\$765,394	11,049,040	\$384,906	

IMPORTS AND EXPORTS OF COPPER (TOTALS ONLY)

Imports			
	Tons	Lb.	Value
Copper ore.....	19,149	5,071,159	\$1,030,541
Copper concentrates.....	14,625	3,777,599	852,901
Copper, matte and regulus.....	4,310	4,975,442	1,100,143
Copper, unrefined.....		33,369,626	7,754,203
Copper, refined.....		202,375	50,594
Copper, old, scrap, etc.....		512,866	83,630
Copper composition metal.....		3,701	611
Exports			
	Tons	Lb.	Value
Copper ore.....	30	4,200	\$600
Copper concentrates, matte, etc.....		108	52
Copper, unrefined.....		30,454,013	7,625,443
Copper, refined.....		79,643	22,016
Copper, old and scrap.....			
Copper, pipes and tubes.....		490,979	206,772
Copper, plates and sheets.....		3,812,266	1,084,758
Copper wire, except insulated.....		5,914,617	1,819,806
Copper, a. o. manufactures.....			344,901

U. S. IMPORTS OF TIN BARS, BLOCKS, PIGS, ETC., BY COUNTRIES AND DISTRICTS—TOTAL IMPORTS OF TIN ORE

Countries	Lb.	Value
England.....	56,000	\$43,377
Straits Settlements.....	6,092,721	3,990,533
Hongkong.....	56,056	36,338
Australia.....	67,200	47,784
Total.....	6,271,977	\$4,118,032
Districts		
	Lb.	Value
Massachusetts.....	168,085	\$127,493
New York.....	291,629	209,025
Pittsburgh.....	56,000	44,893
San Francisco.....	414,721	321,046
Oregon.....	56,400	36,490
Washington.....	4,784,544	3,042,120
Chicago.....	444,542	300,627
St. Louis.....	56,056	36,338
Total.....	6,271,977	\$4,118,032
Tons		
		Value
Total imports of tin ore.....	1,451	\$884,411

IMPORTS AND EXPORTS OF PLATINUM, IRIIDIUM, ETC., BY COUNTRIES

Imports				
Countries	Platinum Ore		Platinum Ingots, Etc.	
	Oz. Troy	Value	Oz. Troy	Value
France.....	550	\$68,668	..	.....
England.....	114	13,838	..	.....
Canada.....	26	3,165	55	\$5,075
Cuba.....	8	827	..	.....
Colombia.....	2,535	196,732	..	.....
Venezuela.....	10	1,053	..	.....
Japan.....	80	6,979	..	.....
Russia in Asia.....	400	35,000	..	.....
New Zealand.....	2	206	..	.....
British South Africa.....	17	1,533	..	.....
Total.....	3,742	\$328,001	55	\$5,075
Iridium				
Countries	Oz. Troy	Value		
England.....	1,355	\$142,103		
Canada.....	5	425		
Australia.....	99	13,585		
Total.....	1,459	\$156,113		
Exports				
Countries	— Unmanufactured —		Manufactured Value	
	Oz. Troy	Value		
Norway.....	.....	.....	\$150	
Canada.....	.....	.....	576	
Chile.....	.....	.....	51	
Peru.....	.....	.....	365	
Total.....	.....	.....	1,142	

U. S. IMPORTS OF LEAD AND ZINC, BY COUNTRIES, AND EXPORTS (TOTALS ONLY)

Imports			
Articles and Countries	Gross Weight, Tons	Contents, Lb.	Value
Lead ore:			
Canada.....	352	329,802	\$17,373
Panama.....	1	166	9
Mexico.....	2,203	170,950	7,710
Peru.....	12	19,093	940
Total.....	2,568	520,011	\$26,032
Lead bullion and base bullion:			
Mexico.....	13,682,443	13,226,678	\$594,812
Lead pigs, bars, etc.:			
Canada.....		13,746	189
Guatemala.....		7,009	421
Zinc ore, etc.:			
Canada.....	623	430,166	9,961
Mexico.....	5,519	4,197,697	73,518
Zinc blocks, etc.:			
Canada.....		18	2
Zinc dust:			
Foreign Exports (Totals)			
Lead ore.....			
Lead bullion.....			
Lead pigs and bars.....		259,051	41,317
Zinc ore.....			
Zinc dust.....			
Domestic Exports (Totals)			
Lead pigs—domestic ore.....		5,454,105	435,876
Lead pigs—foreign ore.....		8,260,586	498,422
Zinc spelter—domestic ore.....		17,372,468	2,419,168
Zinc spelter—foreign ore.....		4,259,622	382,631
Zinc in sheets.....		9,320,666	1,159,536

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET APRIL 8, 1919

Acetic anhydride.....	lb.	.65	—	.70
Acetone.....	lb.	.15	—	.16
Acid, acetic, 28 per cent.....	cwt.	3.00	—	3.25
Acetic, 56 per cent.....	cwt.	6.00	—	6.50
Acetic, glacial, 99½ per cent, carboys.....	cwt.	13.00	—	14.00
Boric, crystals.....	lb.	.13	—	.15
Boric, powder.....	—	—	—	—
Hydrochloric, tech. 20 deg.....	cwt.	2.50	—	3.00
Hydrofluoric, 52 deg.....	lb.	.08	—	.08½
Lactic, 44 per cent, tech.....	lb.	.12	—	.13
Lactic, 22 per cent, tech.....	lb.	.05	—	.06
Molybdic, C. P.....	lb.	6.90	—	7.40
Nitric, 40 deg.....	lb.	.04	—	.07
Nitric, 42 deg.....	lb.	.07	—	.08
Oxalic, crystals.....	lb.	.26	—	.28
Phosphoric, Ortho, 50 per cent, solution.....	lb.	.07	—	.10
Picric.....	lb.	.50	—	.60
Pyrogallol, resublimed.....	lb.	2.70	—	3.20
Sulphuric, 60 deg tank cars.....	ton	12.00	—	13.00
Sulphuric, 60 deg drums.....	ton	17.00	—	—
Sulphuric, 60 deg carboys.....	ton	20.00	—	—
Sulphuric, 66 deg tank cars.....	ton	17.00	—	20.00
Sulphuric, 66 deg drums.....	ton	21.00	—	—
Sulphuric, 66 deg carboys.....	ton	25.00	—	—
Sulphuric, fuming, 20 per cent, (oleum) tank cars.....	ton	22.00	—	25.00
Sulphuric, fuming, 20 per cent, (oleum) drums.....	ton	25.00	—	—
Sulphuric, fuming, 20 per cent, (oleum) carboys.....	ton	30.00	—	—
Tannic, U. S. P.....	lb.	1.40	—	1.50
Tannic, (tech).....	lb.	.60	—	.89
Tartaric, crystals.....	lb.	.88	—	.89
Tungstic, per lb. of Wo.....	gal.	1.60	—	1.75
Alcohol, Amyl.....	gal.	4.85	—	4.90
Alcohol, Methyl.....	gal.	1.28	—	1.30
Alum, ammonia lump.....	lb.	.04	—	.05
Alum, potash lump.....	lb.	.18	—	.19
Alum, chrome lump.....	lb.	.17	—	.18
Aluminium sulphate, commercial.....	lb.	.01	—	.02
Aluminium sulphate, iron free.....	lb.	.02	—	.03
Aqua ammonia, 26 deg, carboys.....	lb.	.06	—	.09
Ammonia, anhydrous.....	lb.	.30	—	.35
Ammonium carbonate, powder.....	lb.	.13	—	.13
Ammonium chloride, granular (white sal ammoniac).....	lb.	.12	—	.13
Ammonium chloride, granular (gray sal ammoniac).....	lb.	.14	—	.16
Ammonium nitrate.....	lb.	.16	—	.17
Ammonium sulphate.....	lb.	.04	—	.05
Amyl acetate.....	gal.	3.50	—	3.75
Arsenic, oxide, lumps.....	lb.	.30	—	.32
Arsenic, sulphate, powdered.....	lb.	.30	—	.32
Barium chloride.....	lb.	70.00	—	80.00
Barium dioxide (peroxide).....	lb.	.22	—	.11
Barium nitrate.....	lb.	.10	—	.04
Barium sulphate (precip.) (chance fine).....	lb.	.03	—	.04
Bleaching powder, (see calcium hypochlorite).....	—	—	—	—
Blue Vitriol (see copper sulphate).....	lb.	.08	—	—
Borax, (see sodium borate).....	—	—	—	—
Bromine, (see sulphur, roll).....	—	—	—	—
Bromine.....	lb.	.55	—	.60
Calcium acetate.....	lb.	.04	—	.05
Calcium carbide.....	lb.	.05	—	.06
Calcium chloride, fused, lump.....	ton	19.00	—	21.00
Calcium chloride, granulated.....	lb.	.02	—	.02
Calcium hypochlorite, (bleaching powder).....	cwt.	1.40	—	2.00
Calcium phosphate-monobasic.....	lb.	.22	—	.21
Calcium peroxide.....	lb.	1.50	—	1.70
Calcium sulphate, precipitate.....	lb.	.09	—	.09
Carbon bisulphide.....	lb.	.07	—	.08
Carbon tetrachloride, drums.....	lb.	.14	—	.15
Carbonyl chloride (phosgene).....	lb.	.75	—	1.00
Caustic potash, (see potassium hydroxide).....	lb.	.42	—	—
Caustic soda, (see sodium hydroxide).....	—	—	—	—
Chlorine, gas, liquid-cylinders, (100 lb.).....	lb.	.08	—	.10
Cobalt oxide.....	lb.	1.60	—	1.65
Copperas (see iron sulphate).....	—	—	—	—
Copper carbonate, green precipitate.....	lb.	.28	—	.31
Copper cyanide.....	lb.	.65	—	.70
Copper sulphate, crystals.....	lb.	.07	—	.07
Cream of tartar, (see potassium bitartrate).....	lb.	.58	—	.59
Epsom salt, (see magnesium sulphate).....	—	—	—	—
Formaldehyde, 40 per cent.....	lb.	.22	—	.22
Glauber's salt (see sodium sulphate).....	—	—	—	—
Glycerine.....	lb.	.16	—	.17
Iodine, resublimed.....	lb.	4.25	—	4.30
Iron oxide, red.....	lb.	.06	—	.08
Iron sulphate (copperas).....	lb.	.01	—	.02
Lead acetate, normal.....	lb.	.12	—	.14
Lead arsenate (paste).....	lb.	.15	—	.18
Lead nitrate, crystals.....	lb.	.85	—	.86
Litharge.....	lb.	.09	—	.10
Lithium carbonate.....	lb.	1.50	—	—
Magnesium carbonate, technical.....	lb.	.15	—	.16
Magnesium sulphate.....	100 lb.	2.25	—	2.35
Nickel salt, double.....	lb.	.14	—	.13
Nickel salt, single.....	lb.	.16	—	.15
Phosgene (see carbonyl chloride).....	—	—	—	—
Phosphorus, red.....	lb.	.75	—	.80
Phosphorus, yellow.....	lb.	.35	—	.40
Potassium bichromate.....	lb.	.54	—	.55
Potassium bitartrate, (cream of tartar).....	lb.	.58	—	.59
Potassium bromide, granular.....	lb.	1.25	—	1.26
Potassium carbonate, U. S. P.....	lb.	.17	—	.18
Potassium carbonate, crude.....	lb.	.14	—	—
Potassium chlorate, crystals.....	lb.	.35	—	.40
Potassium cyanide, 98-99 per cent.....	lb.	Nominal	—	.45
Potassium hydroxide, (caustic potash).....	lb.	.42	—	.55
Potassium iodide.....	lb.	3.50	—	3.55
Potassium nitrate.....	lb.	.20	—	.22
Potassium permanganate.....	lb.	.60	—	.75
Potassium prussiate, red.....	lb.	.85	—	.95
Potassium prussiate, yellow.....	lb.	.45	—	.55
Potassium sulphate.....	ton	Nominal	—	—
Rochelle salts (see sodium potas. tartrate).....	—	—	—	—
Sal ammoniac, (see ammonium chloride).....	lb.	.14	—	.16
Salt soda (see sodium carbonate).....	—	—	—	—
Salt cake (see sodium bisulphate).....	—	—	—	—
Silver cyanide.....	oz.	.63	—	.65
Silver nitrate.....	oz.	1.50	—	1.55
Soda ash, light.....	100 lb.	1.50	—	1.55

Soda ash, dense.....	100 lb.	2.45	—	3.00
Sodium acetate.....	lb.	.07	—	.07½
Sodium bicarbonate.....	100 lb.	2.35	—	2.50
Sodium bichromate.....	ton	12.00	—	14.00
Sodium bisulphate, (salt cake).....	ton	.09	—	.10
Sodium bisulphate.....	lb.	.05	—	.07
Sodium borate, (borax).....	lb.	.07½	—	.08
Sodium carbonate (sal soda).....	100 lb.	1.60	—	2.00
Sodium chlorate.....	lb.	.16	—	.18
Sodium cyanide.....	lb.	.30	—	.31
Sodium fluoride.....	lb.	.14	—	.15
Sodium hydroxide, (caustic soda).....	100 lb.	2.50	—	2.65
Sodium molybdate.....	lb.	2.50	—	—
Sodium nitrate.....	100 lb.	4.07	—	—
Sodium nitrite.....	lb.	.13	—	.14
Sodium peroxide, powdered.....	lb.	.25	—	.30
Sodium phosphate, dibasic.....	lb.	.03½	—	.03½
Sodium potassium tartrate (rochelle salts).....	lb.	.43	—	.45
Sodium prussiate, v-flow.....	lb.	.18	—	.22
Sodium silicate, solution (40 deg).....	lb.	.02½	—	.04½
Sodium silicate, solution (60 deg).....	lb.	.03½	—	.04½
Sodium sulphate, crystals, (Glauber's salt).....	lb.	.01	—	.02
Sodium sulphide, crystal, 60-62 per cent, (conc).....	lb.	.04	—	.05
Sodium sulphite, crystals.....	lb.	.05	—	.06
Strontium nitrate, crystals.....	lb.	.25	—	.30
Sulphur chloride.....	lb.	.07	—	.09
Sulphur, crude.....	ton	35.00	—	37.50
Sulphur dioxide, liquid, cylinders.....	lb.	.10	—	.12
Sulphur, (sublimed) flowers.....	100 lb.	3.05	—	3.15
Sulphur, roll, (brimstone).....	100 lb.	2.70	—	3.10
Tin bichloride, (stannous).....	lb.	.22	—	.25
Tin oxide.....	lb.	.63	—	.66
Zinc carbonate, precipitate.....	lb.	.18	—	.20
Zinc chloride, gran.....	lb.	.13	—	.14
Zinc cyanide.....	lb.	.49	—	.50
Zinc dust.....	lb.	.12	—	.13
Zinc oxide, dry American.....	lb.	.09	—	.11
Zinc sulphate.....	lb.	.03	—	.04

Coal Tar Products—Intermediates, etc.

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude.....	lb.	1.00	—	1.10
Alpha naphthol, refined.....	lb.	1.50	—	1.25
Alpha naphthylamine.....	lb.	.40	—	.45
Aniline oil, drums extra.....	lb.	.22	—	.24
Aniline salts.....	lb.	.32	—	.34
Anthracene, 80% in drums (100 lb.).....	lb.	\$0.50	—	\$.75
Benzaldehyde (f.f.c.).....	lb.	1.30	—	1.50
Benzidine, base.....	lb.	1.00	—	1.15
Benzidine, sulphate.....	lb.	.95	—	1.10
Benzoic acid, U. S. P.....	lb.	1.00	—	1.25
Benzoate of soda, U. S. P.....	lb.	1.00	—	1.25
Benzol, pure, water-white, in drums (100 lb.).....	gal.	.22	—	.27
Benzol, 90%, in drums (100 lb.).....	gal.	.22	—	.27
Benzyl chloride, 95-97%.....	lb.	.35	—	.38
Beta naphthol benzene.....	lb.	5.50	—	6.00
Beta naphthol, sublimed.....	lb.	.65	—	.75
Beta naphthylamine, sublimed.....	lb.	2.25	—	2.35
Cresol, U. S. P., in drums (100 lb.).....	lb.	.18	—	.25
Ortho-cresol, in drums (100 lb.).....	lb.	.23	—	.25
Cresylic acid, 97-99%, straw color, in drums.....	gal.	.90	—	.95
Cresylic acid, 95-97%, dark, in drums.....	gal.	.85	—	.90
Cresylic acid, 50%, first quality, drums.....	gal.	.60	—	.65
Dichlorobenzol.....	lb.	.15	—	.20
Diethylaniline.....	lb.	2.25	—	2.75
Dinitrobenzol.....	lb.	.28	—	.33
Dinitrochlorobenzol.....	lb.	.30	—	.35
Dinitronaphthalene.....	lb.	.45	—	.55
Dinitrotoluol.....	lb.	.40	—	.50
Dinitrophenol.....	lb.	.32	—	.34
Dimethylaniline.....	lb.	.55	—	.60
Dip oil, 25% tar acids, car lots, in drums.....	gal.	.38	—	.45
Diphenylamine.....	lb.	.70	—	.75
H-acid.....	lb.	2.10	—	2.15
Metaphenylenediamine.....	lb.	1.55	—	1.75
Monochlorobenzol.....	lb.	.12	—	.14
Naphthalene, flake.....	lb.	.07	—	.08
Naphthalene, balls.....	lb.	.10	—	.11
Naphthionic acid, crude.....	lb.	1.20	—	1.30
Naphthalene, crushed in bbls. (250 lb.).....	lb.	.07	—	.08
Naphthylamine-di-sulphonic acid.....	lb.	1.00	—	1.10
Nitro naphthalene.....	lb.	.40	—	.45
Nitro toluol.....	lb.	.40	—	.45
Ortho-amidophenol.....	lb.	6.00	—	7.00
Ortho-dichlor-benzol.....	lb.	.15	—	.20
Ortho-toluidine.....	lb.	.40	—	.45
Ortho-nitro-toluol.....	lb.	.35	—	.40
Para-amidophenol, base.....	lb.	3.25	—	3.75
Para-amidophenol, H. C. I.....	lb.	3.25	—	3.75
Para-dichlor-benzol.....	lb.	.15	—	.20
Paranitraniline.....	lb.	1.15	—	1.25
Para-nitro-toluol.....	lb.	1.50	—	1.60
Paraphenylenediamine.....	lb.	3.15	—	3.25
Para-toluidine.....	lb.	1.50	—	1.70
Phthalic acid anhydride.....	lb.	2.50	—	3.00
Phenol, U. S. P. drums (dest.), (240 lb.).....	lb.	.08	—	.10
Pyridin.....	gal.	\$2.50	—	—
Resorcin, technical.....	lb.	4.25	—	4.50
Resorcin, pure.....	lb.	6.75	—	7.00
Salicylic acid, U. S. P.....	lb.	.30	—	.35
Salol.....	lb.	.75	—	.85
Solvent naphtha, water white, in drums, 100 gal.....	gal.	.20	—	.25
Solvent naphtha, crude, heavy, in drums, 100 gal.....	gal.	.18	—	.20
Sulphanilic acid, crude.....	lb.	.25	—	.30
Toluidine.....	lb.	2.15	—	2.25
Toluidine-mixture.....	lb.	.70	—	.75
Toluol, in tank cars.....	gal.	.22	—	.24
Toluol, in drums.....	gal.	.25	—	.27
Xylol, pure, in drums.....	gal.	.37	—	.45
Xylol, pure, in tank cars.....	gal.	.35	—	.40
Xylol, commercial, in drums, 100 gal.....	gal.	.32	—	.40
Xylol, commercial, in tank cars.....	gal.	.30	—	.40

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow.....	lb.	.36	—	.39
Beeswax, refined, yellow.....	lb.	.42	—	.45
Beeswax, white pure.....	lb.	.62	—	.65
Carnauba, No. 1.....	lb.	.78	—	.80

Carnauba, No. 2, regular	lb.	.65	—	.70
Carnauba, No. 2, North Country	lb.	.50	—	.53
Carnauba, No. 3, North Country	lb.	.40	—	.43
Ceresin, yellow	lb.	.15	—	.18
Ceresin, white	lb.	.16	—	.19
Japan	lb.	.14	—	.15
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.07	—	.08
Paraffine waxes, crude scale, 117-119 m.p.	lb.	.08	—	.08
Paraffine waxes, crude scale, 124-126 m.p.	lb.	.08	—	.08
Paraffine waxes, refined, 118-120 m.p.	lb.	.09	—	.10
Paraffine waxes, refined, 123-125 m.p.	lb.	.11	—	.10
Paraffine waxes, refined, 128-130 m.p.	lb.	.11	—	.11
Paraffine waxes, refined, 130-132 m.p.	lb.	.11	—	.11
Paraffine waxes, refined, 133-135 m.p.	lb.	.11	—	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	.12	—	.13
Stearic acid, single pressed	lb.	.17	—	.18
Stearic acid, double pressed	lb.	.18	—	.19
Stearic acid, triple pressed	lb.	.20	—	.22
Spermaceti	lb.	.30	—	.32

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lbs.

Pine oil, steam dist., sp. gr. 0.930-0.940	gal.	\$0.68	—	
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.45	—	
Pine tar oil, ref., sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.33	—	
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.58	—	
Pine tar, ref., thin, sp. gr. 1.080-1.960	gal.	.38	—	
Turpentine, crude, sp. gr. 0.900-0.970	gal.	.61	—	
Hardwood oil, f.o.b. Mich., sp. gr. 0.960-0.990	gal.	.24	—	
Hardwood oil, f.o.b. Mich., sp. gr. 1.06-1.08	gal.	.24	—	
Pinewood creosote, ref.	gal.	.48	—	

Naval Stores

The following prices are F.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	\$12.50	—	\$12.70
Rosin E-L	280 lb.	12.60	—	13.40
Rosin K-N	280 lb.	13.50	—	14.50
Rosin W. G.-W. W.	280 lb.	15.00	—	15.50
Wood rosin, bbl.	280 lb.	12.25	—	
Spirits of Turpentine	gal.	.77	—	.78
Wood Turpentine, steam dist.	gal.	.72	—	
Wood Turpentine, dest. dist.	gal.	.67	—	
Pine tar pitch, bbls.	200 lb.	8.00	—	8.25
Tar, kiln burned, bbl. (500 lbs.)	bbl.	12.50	—	13.50
Retort tar, bbl.	280 lb.	13.50	—	14.50
Rosin oil, first run	gal.	.68	—	.78
Rosin oil, second run	gal.	.70	—	.80
Rosin oil, third run	gal.	.82	—	.83
Rosin oil, fourth run	gal.	.85	—	.95

SOLVENTS

73-76 deg., steel bbls. (85 lb.)	gal.	\$0.33	—	
70-72 deg., steel bbls. (85 lb.)	gal.	.31	—	
68-70 deg., steel bbls. (85 lb.)	gal.	.30	—	
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23	—	

FISH OIL

Winter pressed Menhaden	gal.	\$0.85	—	
Yellow bleached Menhaden	gal.	.87	—	
White bleached Menhaden	gal.	.89	—	
Blown Menhaden	gal.	.95	—	

Vegetable Oils

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls.	lb.	\$0.22	—	\$0.25
Castor oil, AA, in bbls.	lb.	.24	—	.25
China wood oil, in bbls.	lb.	.18	—	.19
Cocunut oil, Ceylon grade, in bbls.	lb.	.15	—	.15
Cocunut oil, Cochon grade, in bbls.	lb.	.16	—	.17
Corn oil, crude, in bbls.	lb.	.18	—	.17
Cottonseed oil, crude (f.o.b. mill)	lb.	.17	—	
Cottonseed oil, summer yellow	gal.	.21	—	.22
Cottonseed oil, winter yellow	gal.	.23	—	.23
Linseed oil, raw, car lots	gal.	1.50	—	1.53
Linseed oil, raw, tank cars	gal.	1.48	—	1.49
Linseed oil, boiled, car lots	gal.	1.53	—	1.55
Olive oil, commercial	gal.	2.25	—	2.50
Palm, Lagos	lb.	.15	—	.20
Palm, bright red	lb.	.13	—	.18
Palm, Niger	lb.	.12	—	.15
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.18	—	.19
Peanut oil, refined, in bbls.	lb.	.19	—	.21
Rapeseed oil, refined, in bbls.	gal.	1.50	—	1.65
Rapeseed oil, blown, in bbls.	gal.	1.65	—	1.70
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.15	—	.16
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.14	—	.14

Miscellaneous Materials

All Prices F.o.b., N. Y.

Barytes, domestic, white, floated	ton	\$30.00	—	\$36.00
Barytes, off color	ton	22.00	—	27.00
Blanc fixe, dry	lb.	.03	—	.04
Blanc fixe, pulp	ton	30.00	—	45.00
Caecin	lb.	.17	—	
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	35.00	—	
China clay (Kaolin), imported, powdered	ton	60.00	—	
China clay (Kaolin), domestic, lump	ton	15.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	35.00	—	40.00
Feldspar	ton	11.00	—	15.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	35.00	—	37.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	40.00	—	45.00
Fuller's earth, domestic, powdered	ton	30.00	—	40.00
Fuller's earth, imported, powdered	ton		—	
Graphite, domestic	lb.	.06	—	.12
Graphite, Ceylon	lb.	.08	—	.18
Graphite, Madagascar	lb.	.10	—	.15
Graphite, Mexican	lb.	.01	—	.03

Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	None	—	
Shellac, T.N.	lb.	.47	—	.49
Shellac, D.C.	lb.	.73	—	.75
Shellac, V. S. O.	lb.	.72	—	.76
Shellac, Diamond I.	lb.	.72	—	.74
Shellac, orange, fine	lb.	.54	—	.57
Shellac, orange, superfine	lb.	.54	—	.58
Shellac, A.C. garnet	lb.	.57	—	.50
Shellac, bleached, bone dry	lb.	.46	—	.47
Shellac, bleached, fresh ground	lb.	.46	—	.47
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	20.00	—	60.00
Talc, imported	ton	Nominal	—	

Refractories

Following prices are f. o. b. works:

Chrome brick	net ton	\$120.00	at Chester, Penn.
Chrome cement	net ton	65.00	at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40-30	at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38-48	at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50-35.50	at Chewalab, Penn.
Magnesite brick, 9 x 4 x 2 1/2 in.	net ton	80-90	at Chester, Penn.
Silica brick	net ton	45-55	at Mt. Union, Penn.

Ferro-alloys

All prices f. o. b. works.

Ferro-titanium, carbon free	lb.	\$0.40	—	
Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	\$200.00	—	\$300.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.32	—	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.70	—	
Ferro-manganese, 70-80% Mn	gross ton	130.00	—	150.00
Spiegelstein, 16-20% Mn	gross ton	40.00	—	50.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.75	—	3.00
Ferro-silicon, 50%	gross ton	90.00	—	115.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%	gross ton	50.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.30	—	1.60
Ferro-uranium, 35-50% of U.	lb.	7.00	—	
Ferro-vanadium, 30-40%, per lb. of contained V.	lb.	5.50	—	7.00

Resales and overstocks make above prices approximate.

Ores and Semi-finished Products

Chrome ore, 35-40% Cr ₂ O ₃	unit	0.70	—	
Chrome ore, 48% and over	unit	\$1.00	—	\$1.25
Coke, foundry, f.o.b. mines	net ton	4.50	—	5.00
Coke, furnace, f.o.b. mines	net ton	3.75	—	4.75
Petroleum coke, f.o.b. Atlantic seaboard	net ton	16.00	—	16.50
Fluorspar, gravel, f.o.b. mines	net ton	18.50	—	20.00
Manganese ore, 45% Mn and over	unit	.60	—	.85
Manganese ore, chemical (MnO ₂)	gross ton	60.00	—	70.00
Molybdenite, 85% MoS ₂ , per lb. of MoS ₂	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO ₃ and over per unit of WO ₃	unit	8.00	—	10.00
Tungsten, Wolframite, 60% WO ₃ and over, per unit of WO ₃	unit	7.00	—	10.00
Uranium oxide, 96%	lb.		—	
Vanadium pentoxide, 99%	lb.	6.00	—	
Pyrites, foreign, lump	unit	.17	—	
Pyrites, foreign, fine	unit	.17	—	
Pyrites, domestic, fine	unit	.14	—	
Ilmenite, 50% TiO ₂	net ton	30.00	—	
Rutile, 95% TiO ₂	net ton	200.00	—	
Carnotite, minimum 2% U ₃ O ₈ , per lb. of U ₃ O ₈	lb.	3.00	—	3.25

Resales and overstocks make above prices approximate.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	\$7.30	—	
Lump lime, common, including container	300 bbl.	2.65	—	
Common brick, at dock	M.	15.00	—	
Hollow building tile, 8x12x12	M.	194.40	—	
At factory, Perth Amboy, N. J., 12x12x12	M.	291.60	—	
Yellow pine, 3x4 to 8x8, 20-24 ft. long	M.	39.00	—	
Yellow pine, 3x4 to 8x8, 0-4 ft. long at Chicago	M.	38.50	—	
Yellow pine, 3x4 to 8x8, 20-24 ft. long at St. Louis	M.	35.00	—	
Roofings, tar felt (14 lb. per 100 sq. ft.)	ton	50.00	—	
Roofings, tar pitch (in 400-lb. bbl.)	ton	19.00	—	
Roofings, asphalt pitch	ton	30.00	—	
Roofings, asphalt felt	ton	65.00	—	
Roofings, slate-surfaced shingles, per roll of 108 sq. ft.		2.10	—	
Roofings, slate-finished shingles, 100 sq. ft.		5.50	—	
Linseed oil, raw in barrels	gal.	\$1.63	—	
Linseed oil, 5 gal. cans	gal.	1.76	—	
Red lead, dry, 100 lb. keg	lb.	.13	—	
Red lead, in oil, 100 lb. keg	lb.	.14	—	
Red lead, dry, 5 lb. cans	lb.	.13	—	
Red lead, in oil, 5 lb. cans	lb.	.16	—	
White lead, dry and in oil, 100 lb. kegs	lb.	.13	—	
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13	—	
White lead, dry and in oil, 5 lb. cans	lb.	.15	—	

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	\$2.45	—	
Angles, 3 to 6-in., 1-in. thick	100 lb.	2.45	—	
Tees, 3-in. and larger	100 lb.	2.45	—	
Plates	100 lb.	2.66	—	
Rivets, structural, 1-in. and larger	100 lb.	4.20	—	
Rivets, conehead for boilers, 1-in. and larger	100 lb.	4.30	—	
Sheets, No. 28 black	100 lb.	4.35	—	
Sheets, No. 10 blue annealed	100 lb.	3.55	—	
Sheets, No. 28 galvanized	100 lb.	5.70	—	

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

PASADENA—The city will join with South Pasadena and Alhambra in constructing sewerage treatment works on the tri-city sewer farm. Bond will be voted for project. R. V. Orblson, city engineer.

SACRAMENTO—The city plans election in May to vote on \$2,400,000 bonds to purchase a site and build a filtration plant, pumping plant and caisson in the Sacramento River. F. C. Miller, City Hall, engineer.

SAN FRANCISCO—The Sherwin-Williams Co., 601 Canal St., Cleveland, Ohio, plans to build a paint and varnish factory here. Estimated cost between \$250,000 and \$300,000.

Connecticut

BRISTOL—The New-Departure Manufacturing Co., 269 North Main St., has awarded the contract for the construction of a 2-story, 30 x 103-ft. laboratory, to the Torrington Building Co., 197 Water St., Torrington. Estimated cost, \$25,000.

HARTFORD—The Hartford Rubber Works, Park and Bath Aves., has awarded the contract for the construction of a 1½-story, 60 x 79-ft. factory on Bartholomew Ave., to J. H. Grozier Co., 221 Main St. Estimated cost, \$34,000.

STORRS—The State Legislature, Capitol, Hartford, has appropriated \$15,000 to build and equip a temporary laboratory for the Connecticut Agricultural College here.

Iowa

ROCK ISLAND—C. U. Scott & Son, 1338 2nd Ave., Davenport, plan to build a galvanizing, sheet metal and tempering plant on 1st Ave., between 15th and 16th Sts., here.

Kentucky

LEXINGTON—The W. J. Fleischer Petroleum Co., 151 East High St., plans to build a refinery having a daily capacity of from 3,000 to 5,000 barrels.

Louisiana

BATON ROUGE—The Island Oil Co., 62 Cedar St., New York City, a subsidiary of the New York Stock Exchange, Stock Exchange Building, New York City, plans to build a refinery here.

Maryland

HAGERSTOWN—The American Agricultural Chemical Co., capitalized at \$100,000,000, has purchased three farms near here and plans to build a chemical and fertilizer plant.

Massachusetts

CHICOPEE—The Paper Makers' Chemical Co., Holyoke, plans to build a 1- and 2-story, 300 x 500-ft. paper factory on Grattan St., here. Estimated cost, \$100,000.

CLINTON—The city plans to build a filtration system. Parker & Bateman, city engineers.

STOUGHTON—The United States Rubber Co., Broadway and 58th St., plans to build an addition to its factory here.

WORCESTER—The Greenman Steel Treating Co. plans to build a 1-story, 40 x 80-ft. plant.

Michigan

DETROIT—The Board of Water Commissioners, 232 Jefferson Ave., has awarded the contract for furnishing 100,000 lb. of liquid chlorine to the Hooker Electro Chemical Co., 40 Wall St., New York City, N. Y., at \$.05½ per lb.

DETROIT—The General Motors Corp., Boyer-Campbell Bldg., is having plans prepared by A. Kahn, architect, Marquette Bldg., for the construction of a 4-story, 60 x 480-ft. research laboratory building on Cass and Milwaukee Aves., same to be equipped with apparatus for a complete chemical, metallurgical and material testing laboratory.

HIGHLAND PARK—The city will soon award the contract for the construction of a filtration plant, to include a 2-story, 29 x 32-ft. head house and a 3-story, 32 x 85-ft. filter house, for the Dequindre Ave. Station of the Highland Park waterworks. D. C. Gewing, city clerk.

JACKSON—The city is having a study made by Alvord & Burdick, engineers, 8 South Dearborn St., Chicago, Ill., for the construction of a sewage disposal system to consist of deep settling tanks and intercepting sewers.

MONROE—The city plans to build a filtration plant. J. White, city engineer.

Minnesota

KEEWATIN—The city has awarded the contract for building extensions to its sewerage system and a sewage disposal plant to E. W. Coons Construction Co., Hibbing, at \$59,184.

Missouri

CARONDOLET (St. Louis P. O.)—The Mineral Refining & Chemical Corp. will receive bids about June 1 for the construction of a paint and pigment plant on the Mississippi River front. Plans include a chemical laboratory, mineral milling plant, etc. Estimated cost, \$2,500,000. M. Alayo, vice-president.

Nebraska

OMAHA—The Board of Education will install six laboratories in the new High School of Commerce which it plans to build, F. W. Clark, 623 Brandeis Building, architect.

New Jersey

ASBURY PARK—The Victory Tire & Rubber Co., 385 East 149th St., New York City, N. Y., plans to build a 2-story rubber factory on Railroad Ave. Estimated cost, \$125,000. E. A. Arend, Kinmoth Building, architect.

HILLSDALE—The Bristol-Myers Co., 277 Greene Ave., Brooklyn, N. Y., has awarded the contract for the construction of a 1-story, 75 x 95-ft. extension to its chemical building, and a 5-story, 80 x 300-ft. manufacturing building, to the Turner Construction Co., 244 Madison Ave., New York City, N. Y.

TRENTON—The city plans to build a 2-story alum plant on Enterprise Ave. Estimated cost, \$10,000. J. R. Fell, 134 North Clinton Ave., engineer.

New York

BROOKLYN—The Polytechnic Institute, 85 Livingston St., is in the market for two steel measuring or storage tanks, to be installed in its hydraulic laboratory for cold water storage.

GREENFIELD—The Waco Development Co., recently incorporated, plans to build a plant here. Mining machinery for feldspar mining will be installed in same. Address E. H. Cohen, 236 Union St., Schenectady.

MALDEN BRIDGE—The Gatti-McQuade Paper Co., 200 5th Ave., New York City, has purchased the Peaslee Mills here and is having plans prepared for repairing and altering same for its own use. Estimated cost, \$25,000.

MILTON—The Waco Development Co., recently incorporated, plans to build a plant here. Mining machinery for feldspar mining will be installed in same. Address E. H. Cohen, 236 Union St., Schenectady.

NEW YORK—The Crystal Chemical Co., 861 Westchester Ave. (Bronx Borough),

has awarded the contract for altering its 6-story, 40 x 70- and 30 x 42-ft. factory at 142-146 Willis Ave., to W. L. Phelan, 2045 Ryer Ave. Estimated cost, \$25,000.

ROCHESTER—The Industrial Development Committee, Chamber of Commerce, is having plans prepared for a large shipyard on the lower Genesee River near lake harbor. A cement testing laboratory will be installed in same.

ROCHESTER—The Technical Glass Apparatus Co., Inc., plans to extend its facilities and install new machinery for the manufacture of scientific and laboratory glassware. F. C. Mueller, president.

TUCKAHOE—The Hodgeman Rubber Co. has awarded the contract for the construction of a 1-story, 50 x 150-ft. factory to Kelly & Kelly, East 12th St. and Vernon Ave., Long Island City. Estimated cost, \$15,000. Noted Mar. 15.

North Carolina

BREVARD—The Transylvania Tanning Co. plans to rebuild its plant recently destroyed by fire, entailing a loss of \$1,000,000.

Ohio

AKRON—The Mohawk Rubber Co., 2nd Ave., has awarded the contract for the construction of a 60 x 200-ft. rubber factory to W. A. Franklin Sons Co., 247 Cuyahoga St. Estimated cost, \$50,000.

CINCINNATI—The city plans to build a garbage incinerator. Bonds must be voted for the project. F. Krug, city engineer.

CLEVELAND—The Commissioner of Purchases & Supplies, Room 219, City Hall, will receive bids until May 6 for the construction of a sewage disposal plant on West 58th St. (westerly site).

COLUMBUS—The American Rolling Mills Co. is receiving bids for extensive remodeling and new construction work at its plant along the tracks of the Toledo & Ohio Central R.R. on Parsons Ave. Work includes relining two furnaces, putting in eight hot-blast stoves, raising number of former stoves and building gas dry cleaning plant. Estimated cost between \$300,000 and \$400,000. J. C. Miller, Middletown, local manager.

NEWPORT—The city plans to build a garbage incinerator.

WAUSEON—The city plans election soon to vote on \$170,000 for the construction of a water supply and filtration plant.

Pennsylvania

BEAVER FALLS—The city plans an election soon to vote on \$125,000 bonds; part of proceeds to be used for the construction of a new sewage disposal plant. H. T. Barker, city clerk.

ELLWOOD CITY—The city plans an election soon to vote on \$85,000 bonds; part of proceeds will be used for the construction of a disposal plant.

REYNOLDSVILLE—The Elk Tanning Co. plans to enlarge its plant here.

Texas

DALLAS—The Texas Producing & Refining Co., recently incorporated with \$5,000,000 capital, plans to build an oil refinery here. The plant will be constructed in units, the first to have a capacity of 4000 bbl. daily, with other units added until the ultimate capacity will reach 15,000 bbl. daily. J. F. Smith, Southwestern Life Building, president.

DUBLIN—The State Refining Association has purchased a site here and plans to build an oil refinery. B. R. Anderson, president.

EASTLAND—The Alamo Oil & Refining Co. has purchased a site and plans to build a 1200-bbl. oil refinery.

EL PASO—Z. T. White, 527 First National Bank Bldg., and associates plan to build a 3000-bbl. oil refinery here.

FT. WORTH—F. P. Peterson, 307 West 4th St., and others, plan to form a company and build a plant for the manufacture of paints, grease, lubricating oils and floor sweep compound, on a site now occupied by the Brewton Oil Co., North Main St. and the Frisco tracks.

HOUSTON—The Galena-Signal Oil Co., 17 Battery Pl., New York City, N. Y., plans to increase the capacity of its oil refinery on the ship channel, near here, to 16,000 bbl. per day.

RANGER—The city has awarded the contract for the construction of a new

sewerage system and sewage disposal plant to the James Construction Co., 812 2nd Ave. N., Seattle, Wash. Estimated cost, \$155,000. Noted Feb. 1.

Utah

CASTLEGATE—The Rainbow Petroleum Products Co., 4th and 5th West and 7th and 8th South Sts., Salt Lake City, plans to build the first unit of its new plant on the oil shale property near here, same to have a daily capacity of 100 tons.

Virginia

NORFOLK—The Mexican Petroleum Corp., Whitney Bldg., New Orleans, La., plans to build a plant here. W. E. Wimbish, manager.

PETERSBURG—W. H. Camp, Inc., Wharf, plans to build a 1-story fertilizer plant, and is in the market for machinery for mixing chemicals. Estimated cost, \$55,000.

West Virginia

MARTINSBURG—The city plans to build a sewerage system and sewage disposal plant. T. W. Sparrow, city engineer.

Wisconsin

GREEN BAY—Kimberly & Clark, Nee-nah, plans to build a 2-story, 30 x 90-ft. addition to its paper mill here. Estimated cost, \$20,000.

MANITOWOC—The Aluminum Goods Manufacturing Co., 150 Franklin St., has awarded the contract for the construction of a 6-story, 70 x 430-ft. factory and office building to W. W. Oeffeln, 136 Hanover St., Milwaukee. Estimated cost, \$500,000.

SHEBOYGAN—The Dodge Tanning Co., South Water St., has awarded the contract for the construction of a 3-story, 100 x 250-ft. tannery to H. Loesing, 914 Superior Ave. Estimated cost, \$60,000.

TWO RIVERS—The Aluminum Goods Manufacturing Co., 150 Franklin St., Manitowoc, has awarded the contract for the construction of two 3-story, 60 x 300 and 43 x 137-ft. factory buildings to W. W. Oeffeln, 136 Hanover St., Milwaukee. Estimated cost, \$500,000.

Ontario

DUNDAS—The Town Council plans to build a sewage disposal plant. Estimated cost, \$50,000. J. S. Fry, clerk.

TORONTO—W. Harris & Co. will soon receive bids for the construction of a 4-story, 66 x 145-ft. glue factory on Keating St. A. Chapman, Harbor Building, architect.

Quebec

LAC AU SAUMON—The Salmon Lake Drive & Boom Association, Ltd., plans to build a large wood and pulp plant.

Mexico

PALO BLANCO—The Island Oil Co., 62 Cedar St., New York City, N. Y., a subsidiary of the New York Stock Exchange, Stock Exchange Bldg., New York City, plans to build a refinery here.

Coming Meetings and Events

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its Summer meeting at Boston, Mass., June 18-21. A symposium is planned on electric furnaces.

THE AMERICAN ASSOCIATION OF ENGINEERS will hold a meeting at 29 S. LaSalle St., Chicago, May 13 and 14.

THE AMERICAN IRON & STEEL INSTITUTE will hold its next meeting on May 23-24 at the Hotel Pennsylvania, New York.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 22nd annual meeting at Atlantic City, N. J., June 24-27. The headquarters will be at the Hotel Traymore.

THE AMERICAN ZINC INSTITUTE will hold its annual meeting at St. Louis, Mo., June 9-10.

THE NATIONAL FERTILIZER ASSOCIATION will hold its 26th annual convention the week of June 23 at the Hotel Griswold, Eastern Point, New London, Conn.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its Spring meeting, June 11-14 inclusive.

THE NEW JERSEY CHEMICAL SOCIETY will hold its Spring invitation meeting in the

Chemical Building, Rutgers College, New Brunswick, N. J., Saturday, May 10, 1919. Dinner will be served in the University dining hall at 7 P. M.

Industrial Notes

MR. OTTO MANTIUS has moved his offices from the Woolworth Bldg. to 15 East 40th St., New York City.

MR. FREDERICK H. MINARD announces that on May 1 his offices will be moved to larger quarters at 21 East 40th St., New York City.

THE CHICAGO PNEUMATIC TOOL CO., Chicago, Ill., announces the appointment of Mr. T. J. Hudson as acting manager of the pneumatic tool sales division, effective April 15, 1919, succeeding Mr. F. H. Waldron, who returns to Minneapolis as district manager of sales in that territory.

THE SCHAFER ENGINEERING & EQUIPMENT CO. has changed its location from Tiffin, Ohio, to the Peoples Bank Bldg., Pittsburgh, Pa.

MR. FRANK H. NICKLE, Saginaw, W. S. Mich., has placed on the market several styles of agitator driving yokes, suitable for all kinds of liquid containers.

New Publications

NEW UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS: Natural-Gas Gasoline in 1917. By John D. Northrop (Mineral Resources, 1917, Part II), published March 17, 1919; I:II, Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1917. By Charles W. Henderson (Mineral Resources, 1917, Part I), published Jan. 27, 1919; I:12, Gold, Silver, Copper, Lead and Zinc in Utah in 1917. By V. C. Heikes (Mineral Resources, 1917, Part I), published Feb. 8, 1919; I:13, Gold, Silver, Copper, Lead and Zinc in California and Oregon in 1917. By Charles G. Yale (Mineral Resources, 1917, Part I), published Feb. 13, 1919; I:14, Gold, Silver, Copper, Lead, and Zinc in Nevada in 1917. By V. C. Heikes (Mineral Resources, 1917, Part I), published Feb. 18, 1919; I:15, Secondary Metals in 1917. By J. P. Dunlop (Mineral Resources, 1917, Part I), published Feb. 19, 1919; I:16, Gold, Silver, Copper, Lead and Zinc in Montana in 1917. By V. C. Heikes (Mineral Resources, 1917, Part I), published Feb. 21, 1919; I:24, Quicksilver in 1916. By H. D. McCaskey (Mineral Resources, 1916, Part I), published Feb. 19, 1919; I:25, Cobalt, Molybdenum, Nickel, Titanium, Tungsten, Radium, Uranium and Vanadium in 1916. By Frank L. Hess (Mineral Resources, 1916, Part I), published Feb. 25, 1919; I:23, Sodium Salts in 1917. By Roger C. Wells (Mineral Resources, 1917, Part II), published Jan. 27, 1919; I:24, Cement in 1917. By Ernest F. Burchard, with a section on concrete ships by Robert W. Lesley (Mineral Resources, 1917, Part II), published Feb. 4, 1919; I:25, Sand and Gravel in 1917. By R. W. Stone (Mineral Resources, 1917, Part II), published Feb. 21, 1919; I:26, Potash in 1917. By Hoyt S. Gale and W. B. Hicks (Mineral Resources, 1917, Part II) published March 13, 1919.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 174, Abstracts of Current Decisions on Mines and Mining, reported from May to September, 1918. By J. W. Thompson; Tech. Paper 96, Fume and Other Losses in Condensing Quicksilver from Furnace Gases. By L. H. Duschak and C. N. Schuette; Tech. Paper 203, Labor Saving at Limestone Quarries. By Oliver Bowles; Tech. Paper 215, Accidents at Metallurgical Works in the United States During the Calendar Year 1917. Compiled by Albert H. Fay; Tech. Paper 217, Saving Coal in Steam Power Plants. Reprint of Engineering Bull. No. 2, prepared by the U. S. Fuel Administration in collaboration with the Bureau of Mines; Tech. Paper 221, Saving Steam in Industrial Heating Systems. Reprint of Engineering Bull. No. 6, prepared by the U. S. Fuel Administration in collaboration with the Bureau of Mines; War Minerals series No. 10, Electric Smelting of Domestic Manganese Ores. By H. W. Gillett and C. E. Williams; Schedule No. 13, March 5, 1919. Procedure for Establishing a List of Permissible Self-Contained Mine Rescue Breathing Apparatus.

NEW BUREAU OF STANDARDS PUBLICATIONS: Technologic Paper No. 109, Conservation of Tin in Bearing Metals, Bronzes, and Solders. By G. K. Burgess and R. W. Woodward, issued March 15, 1919; Circular No.

78, Solders for Aluminium, issued Jan. 28, 1919; Technologic Paper No. 114, A Portable Cubic-Foot Standard for Gas. By M. H. Stillman, issued January 28, 1919, price, 5 cents.

THE YOUNGSTOWN PUBLIC LIBRARY has inaugurated a service for vocational study that may well be copied by other city libraries. It has issued a 12-page booklet on the industries of Youngstown, put up in an attractive two-color cover carrying an industrial design of a blast-furnace plant. The following subjects are covered: General engineering, mechanical engineering, steam engineering, electrical engineering, machine design, machine shop practice, general chemistry, analytical chemistry, industrial chemistry, fuels, coal-tar by-products, general metallurgy, iron and steel, electric furnaces, rubber, etc.

"THE SURFACE OXIDATION AND COLORATION OF METALS" is the subject of a pamphlet published by Dr. Tito Rondelli, 31 Via Carlo Alberto, Turin, Italy, setting forth the details of the "Sestini-Rondelli" electrolytic process.

Stocks and Bonds

Closing Bid and Asked Quotations April 25, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am. Ag. Ch.	100 1/2	100 3/4	Mat. Al. Wk.	31	36
do. pf.	99	100	Ten. C. & C.	14 1/2	14 1/2
Barrett Co.	127	128	Un. Dyewood.	60	61
do. pf.	114	115	do. pf.		96
Gen. Chem.	170	180	Va.-Car. Ch.	51 1/2	51 1/2
do. pf.	102 1/2	103 1/2	do. pf.	111 1/2	112 1/2
Int. Ag. Ch.	18 1/2	19 1/2			
do. pf.	7 1/2	7 3/4			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28	98 1/2	99 1/2
Am. Ag. Ch., cv. db. 5s, '24	104	105
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32	81 1/2	81 1/2
Va.-Car. Ch., 1 mtg. 5s, '23	95 1/2	95 1/2
Va.-Car. Ch., cv. db. 6s, '24	101 1/2	101 1/2

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co.	81 1/2	82	P-A Pet & Tr.	82 1/2	83
Cal. Pet.	27 1/2	27 3/4	do. pf.	144	146
do. pf.	71	72	Pierce Oil.	24	24 1/2
Col. G. & S.	45 1/2	46	Royal Dutch.	99 1/2	99 1/2
Mex. Pet.	181 1/2	182	Sinclair O & R	55 1/2	55 1/2
do. pf.	107	110	Texas Co.	218 1/2	219
Ohio Cit. Gas.	40 1/2	41	Tex. Pac. Ld.		
do. pf.			Tr.	280	325
Ohio Fuel S.	47 1/2	48	Tidewater Oil.	227	230
Okl. P. & R.	10 1/2	10 3/4			

Bonds

Columbia Gas & Electric, 1 5s, '27	84 1/2	85 1/2
Col. G. & E., std. 1 5s, '27	83	89
Pan-Am. Pet. & Tr. 1 5s, '19-'27	130	
Pierce Oil, cv. db. 6s, '24	105	106 1/2
Pierce Oil, cv. 5s, Notes, '20	114	122
Sin. O. & R. 1 In. 7s, '20, with stk. war.	119	121 1/2
Sin. O. & R. 1 In. 7s, '20 without stk. war.	98 1/2	99 1/2
Texas Co., db. 6s, '31	107 1/2	103
Union Oil of Cal. 1 5s, '31	93	94
United Fuel Gas 1 mtg. 6s, ser. A, '36	94 1/2	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F.			Pitta. Ste. pf.	93 1/2	100
Beth. Steel.	73 1/2	75 1/2	Rep. Iron &		
do. class B.	74 1/2	76 1/2	Steel	82	82 1/2
do. pf.	87 1/2	110 1/2	do. pf.	102 1/2	103 1/2
do. pf.	70 1/2	99	Sloss Sheff. I.		54
Central Fdry.	15		& S.	53	54
do. pf.	29		do. pf.	86	90
Col. F. & I.	42 1/2	43 1/2	Superior Steel.	38 1/2	39 1/2
do. pf.	105	125	do. 1 pf.	97	98 1/2
Cru. Steel.	68	68 1/2	Trans. & W.		
do. pf.	93	97	Steel	46 1/2	47
Great No. Ore	43 1/2	44	Un. Alloy St.	42	43
Gulf Sta. Steel	54	55	U.S.C.I.P. & F.	25 1/2	26
do. 1 pf.	92 1/2	98 1/2	do. pf.	53	53 1/2
Lack. Steel.	70 1/2	71 1/2	U. S. Steel	100	100 1/2
Mid. St. & Ord.	45 1/2	45 1/2	do. pf.	115	117
Nova Scotia			Va. Coal & I. C.	55	57
Steel	50	54			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26	96	96 1/2
Beth. Steel, 1 In. ref. 5s, Ser. A, '42	86 1/2	87 1/2
Beth. Steel, P. M. & I. S. F. 5s, '36	85	8 1/2
Buff. & Susq. Iron, 1 S. F. 5s, '32	91	96
Buff. & Susq. Iron, deb. 5s, '27		
Cent. Found. 1 mtg. S. F. 6s, '21	76	80 1/2
Col. F. & I., gn. S. F. 5s, '43	89 1/2	91
Ill. Steel, deb. 4s, '40	84	85
Ind. Steel, 1 mtg. gtd. 5s, '52	96 1/2	97
Lack. Steel, 1 con. mtg. cv. 5s, Ser. A, '50	87	91 1/2
Mid. St. & Ord., cit. cv. S. F. 5s, '36	88 1/2	88 1/2
Nat. Tube, 1 mtg. gtd. 5s, '52	95 1/2	96
Rep. I. & S. S. F. mtg. 5s, '40	93	94
Tenn. C. & I. R.R., gn. 5s, '51	92	95 1/2
U. S. Steel, S. F. 5s, '63	100 1/2	100 1/2
Va. C., I. & C., 1 5s, '49	85	85 1/2